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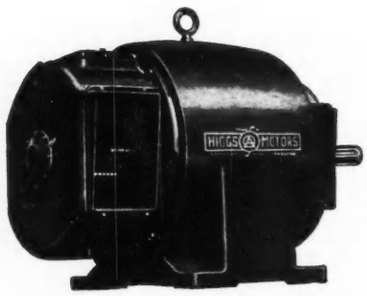

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THE STORY OF ATOMIC ENERGY.

VIII—THE QUANTUM THEORY AND CHEMISTRY.

By DR. FREDERICK SODDY, F.R.S.*

IT is now necessary to review the progress that had been made up to 1912 in the elucidation of the nature of the X-rays. As already mentioned, Einstein's theory of the photo-electric effect indicated that the X-rays were light radiations of very high frequency, because of the very high kinetic energy of the electrons ejected by them from matter—a process which, incidentally, is the exact converse of their formation by bombarding matter with high-speed electrons. The ordinary photo-electrons, emitted by electro-positive metals, such as magnesium, zinc, and the alkali-metals, by light in the near ultra-violet, or, for the last mentioned, of visible frequency, have only one or two electron-volts kinetic energy, whereas those produced by X-rays have sufficient energy to ionise gases.

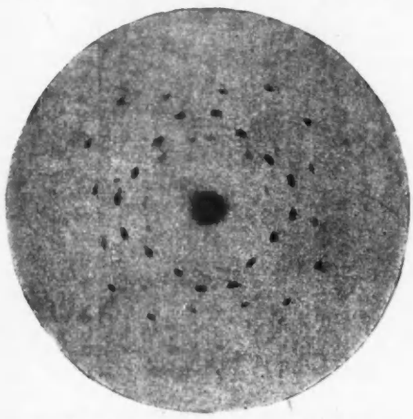


FIG. 45. FIRST LAUE PHOTOGRAPH OF THE DIFFRACTION OF X-RAYS BY ZINC SULPHIDE.

Indeed, the ionisation caused by X-rays is entirely indirect, and is due to these electrons ejected from the gas irradiated, and not directly to the X-rays themselves. Also, attempts to measure the velocity of the X-rays by comparison methods had given the same velocity as for light, though the evidence was at first thought insufficient to establish this beyond doubt.

THE DIFFRACTION OF X-RAYS.

The diffraction gratings used in spectroscopes in lieu of prisms, to resolve ordinary light into its component wavelengths, consist of glass surfaces on which some 20,000 lines per linear inch have been ruled by a diamond, for the spacing of the lines must be of the same order of magnitude as the wavelengths being resolved. In 1912, Laue conceived the idea of using the crystal as a diffraction grating for the X-rays. The crystal is a close-packed assembly of atoms or molecules, according to a regular three-dimensional pattern, called a space-lattice, in which the distances between the centres of the constituent atoms, or molecules, is of the same order as the Ångstrom unit, 10^{-8} cm. The first experiment by Friedrich and Knipping to test this gave, for a crystal of zinc sulphide, a geometrical pattern of black spots on the photographic plate, showing that the X-rays passing through the crystal were, as anticipated by Laue, diffracted as by a three-dimensional grating, the rays being concentrated as strong pencils in certain definite directions. Fig. 45 is a reproduction of the first Laue photograph of the diffraction of X-rays by zinc sulphide. The X-rays were sent through a crystal of zinc sulphide, ½ mm. in thickness, normally to the surface and received on a photographic plate parallel to the face of the crystal. The black spots show the directions in which the rays augment rather than extinguish one another, and they reveal the cubic symmetry of the crystal.

In this country the two Braggs developed from this a perfectly general method of X-ray spectroscopy, in every way analogous to optical spectroscopy by using the crystal as the diffraction grating. This new weapon for research was double-barrelled. For any crystal, the architecture of which was known, the wavelength of any X-ray could be directly determined in Ångstrom units, and, conversely, with any X-ray of known wavelength the space-lattice of any crystal could be directly set out in three dimensions to the scale of Ångstrom units. This scale could be calculated beforehand for simple cubical space-lattice crystals, such as those of rock-salt and sylvine (sodium and potassium chloride) respectively, from their density and Avogadro's Number, and these crystals were the first to be used.

Incidentally, owing to the atomic weights of potassium and chlorine being very near together, and those of sodium and chlorine far apart, though both crystals are in reality what are termed two inter-penetrating face-centred cubic lattices—in which the metal atoms occupy the centres of the six faces of the cube, with the halogen atoms at the corners, and vice versa, in the extended three-dimensional lattices—sylvine behaves as a simple cubic lattice. This is because the diffracting power of the atoms is a function of the atomic weight, and the two kinds of atoms occupying the alternate corners of each of the eight smaller cubes into which the interpenetrating face-centred cubical lattice is divided, behave almost alike to the X-rays. Fig. 46 shows the face-centred cube lattice of sodium chloride. In the lattice, extended indefinitely in all three dimensions, the two types of atom are interchangeable. When the atomic weights are similar, as in the sylvine (potassium chloride) lattice, the two kinds are not differentiated by the X-rays, and the diagram then represents eight small simple cubic lattices in juxtaposition. Here, each atom has six atoms of the other kind surrounding it symmetrically.

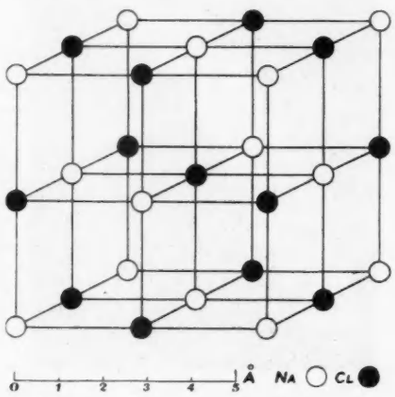


FIG. 46. FACE-CENTRED CUBE LATTICE OF SODIUM CHLORIDE.

This first, almost chance, result proved fundamental in showing that, for this class of "polar" compound, it is the atoms of metal and halogen that form the lattice, and that the individual molecule, NaCl or KCl, does not exist as such in the crystal any more than in the fused salt or the solution, as already mentioned. For each atom of either kind, six of the other kind symmetrically surround it, in all respects exactly alike, so that no one atom has any particular claim to be the partner of the atom in the centre. Curiously, caesium chloride was found later to have a cube-centred lattice, in which an atom of either kind is at the centre of a cube, with eight, instead of six, atoms of the other kind at the corners. Fig. 47 shows the cube-centred cube lattice of caesium chloride. In this the lattice consists of unit cubes with atoms of the one kind at the eight corners and one of the other kind in the centre and, in the extended lattice, the two types of atom are again interchangeable.

The method of X-ray spectroscopy, proper, requires the use of a crystal as the diffraction grating, the architecture of which in the scale of Ångstrom units is exactly known, and such were available in the simple cubical system crystals. Here again the very first results of the Braggs were to be unexpectedly fruitful, for they used as anti-cathodes, in the X-ray tubes they employed, the two light platinum metals, rhodium and palladium, and found that in each case the X-rays were practically homogeneous, each metal giving out a very close doublet, of wavelengths 0·612 Å. and 0·616 Å. for rhodium and 0·584 Å. and 0·589 Å. for palladium, these being consecutive elements Nos. 45 and 46 in the Periodic Table. As later research has shown, there are other lines besides these close doublets, but they are much weaker.

BARKLA'S CHARACTERISTIC HOMOGENEOUS SECONDARY X-RAYS.

Before their exact nature had been thus elegantly revealed by the crystal diffraction method, C. G. Barkla, of Liverpool University, had discovered that X-rays, if sufficiently hard or penetrating, have the power of exciting what he termed charcteristic homogeneous secondary X-rays, when the various elements are irradiated by them. That is to say, the secondary X-rays are homogeneous in nature, or monochromatic as it would be expressed in optics, and are characteristic of the elements irradiated, not at all of the primary X-rays, beyond the requirement that the latter must be harder than the secondary rays emitted. It is in reality the X-ray analogue of fluorescence with light, where the exciting rays must usually be of higher frequency or shorter wavelength than the fluorescent light it produces, but for the X-rays is a perfectly general phenomenon. As for characterisation, the only criterion then was their hardness, or penetrating power, and as to homogeneity, that the rays were exponentially absorbed by metal screens, so that the absorption coefficients provide an exact numerical measure of their penetrating power.

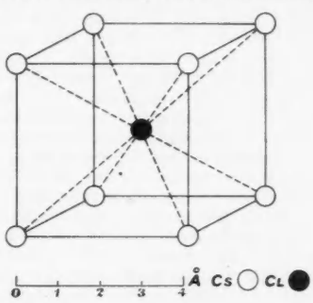


FIG 47 CUBE-CENTRED CUBE LATTICE OF CAESIUM CHLORIDE.

Starting from aluminium, at the light end of the elements in the Periodic Table, Barkla found that the secondary rays generated by the successive elements, at first very soft so that they are strongly absorbed even by gases, became progressively harder, until at atomic weights between 100 and 110, they became too hard to be generated by the hardest primary rays then available. But just before this, which brought this first series—which he termed the K-series—to an end at silver, another series—which he called the L-series—started, the rays being at first excessively soft, but as before progressively hardening. In this case the series can be followed right up to the elements of heaviest atomic weight. Further series of the same general character, known as the M, N, O . . . series, have since been found, each starting at some point farther on in the Periodic Table. These letters are now interesting, as they recall the way the successive rings or shells of the external electrons of the Thomson and nuclear model atoms first revealed themselves.

* We have arranged with Dr. Soddy to publish his new book, *The Story of Atomic Energy*, in the form of a series of articles which are appearing at fortnightly intervals approximately. Dr. Soddy, however, retains the copyright, therefore no extract may be made from these articles without his permission.—ED. E.

Moseley's Law.

Complementary to the work of Bohr on optical spectra was that of H. G. J. Moseley, at Oxford, on X-ray spectra. An Oxford graduate in chemistry, he worked with Rutherford as a research student in Manchester, but was killed, shortly after his work on X-rays appeared, at Suvla Bay, Gallipoli, in the First World War, aged 28—one of the youngest investigators ever to have secured so immortal a place in the history of science. Moseley measured the wavelengths of the principal lines of Barkla's K and L series for the successive elements in the Periodic Table, and so discovered, as a general law, the progressive shortening of the wavelength, and increase of the frequency, of these rays, step by step, in passing from one place in the Periodic Table to the next. Moseley's diagram of the X-ray (K series) spectra of successive elements is shown in Fig. 48. From right to left is the direction of increasing frequency and diminishing wavelength, and each element gives a pair of lines, the stronger being that of the longer wavelength, which diminish in wavelength progressively in passing through the successive elements in the Periodic Table. Scandium, between calcium and titanium, is missing, accounting for the double step; the cobalt spectrum shows the lines of nickel and iron; the lowest spectrum, of brass, shows the lines of copper and zinc. Fig. 49 is a similar illustration by later workers for seven of the elements between and including As and Rh, the line lettered O running through all showing the position of the undiffracted beam. Here there is a gap of one element between Br and Rb, two between Sr and Nb, and three between Nb and Rh.

These Barkla X-rays are the true X-ray spectra of the elements, in every way analogous to their characteristic optical spectra. Moreover, by the extension of Bohr's theory for the hydrogen and helium spectra to the subsequent elements, the progressive change of spectrum from element to element can be related to the square of the nuclear charge, which is the serial number, now called the atomic number, of the element in the Periodic Table. This enabled the atomic number to be experimentally ascertained from the wavelength of the characteristic X-ray emitted by the element.

Here, instead of the "fall" of the electron previously banished by "excitation" from successive exterior orbits into other exterior orbits nearer the central nucleus, as for all optical spectra, we have to do with the fall from the same farther orbit to the same nearer orbit inside the electronic structure of the atom. The K-series is the result of the fall from a No. II orbit, of the L-shell or ring of the atom, into a No. I orbit of the K-shell or ring, while the L-series results from the fall from No. III to No. II, and so on for the others. The progressive shortening of the wavelength is due to the nuclear charge increasing unit by unit in passing from each element to the next. This established van der Broeck's second 1913 suggestion and extended throughout the whole Periodic Table the conception of Atomic Number first arrived at by the Displacement Law for the twelve places at the end from uranium to thallium.

For the K-series, the wave number, ν_K, of the principal line is given by

$$\nu_K = R\left[\frac{1}{1^2} - \frac{1}{2^2}\right](N-1)^2 = \tfrac{3}{4}R(N-1)^2,$$

where N is the Atomic Number of the element and R is Rydberg's constant. So far as the K-ring of the atom is concerned, the L, M, N . . . electrons outside the K-ring hardly count, being nearly symmetrically distributed round the nucleus so that their effects cancel out. The effective nuclear charge of the excited atom which has lost a K-electron is (N — 1), so that the frequency is very nearly proportional to $(N-1)^2$.

For the L-series the relation is not so regular as for the K-series, and is given approximately by

$$\nu_L = R\left[\frac{1}{2^2} - \frac{1}{3^2}\right](N-7{\cdot}4)^2 = \tfrac{5}{36}(N-7{\cdot}4)^2.$$

Here the (N — 7·4) factor may be regarded as the average effective nuclear charge for an atom that has lost one of the eight electrons of the L-shell, but the actual value is subject to a slight progressive change as N increases.

Hafnium and Rhenium.

Moseley's Law had most important results in pure chemistry, as it enabled, for the first time, the roll to be called of the possible elements from hydrogen to uranium, and the places still vacant to be definitely ascertained. At that time there were six, including No. 91, protactinum, discovered in 1918 and already discussed. But, of the other five possible elements, we now believe that only two, named hafnium and rhenium, can permanently exist, the others probably being unstable. The principal lacuna in the Periodic Table had been that it offered no clue whatever to the number of rare-earth elements. As regards these, Moseley's Law indicated that place No. 61 was still vacant, and Bohr, in his subsequent application of the quantum theory to the elucidation of the Periodic Law, definitely predicted that place No. 72, after lutecium, No. 71—the rare-earth element with the highest atomic weight of those known—was not a rare-earth element but a homologue of the tetravalent zirconium in Group IV.

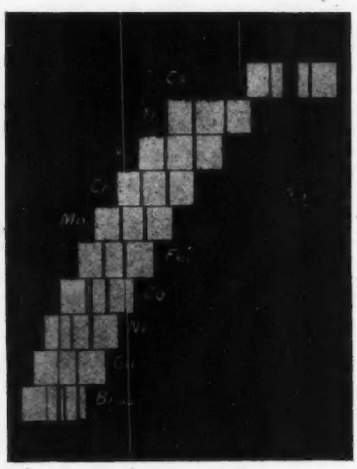


Fig. 48. Moseley Diagram of X-Ray (K Series) Spectra, Calcium to Zinc.

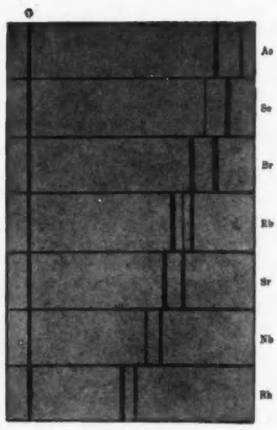


Fig. 49. Moseley Diagram of X-Ray (K Series) Spectra, Arsenic to Rhodium.

Hafnium was discovered in 1923, by Coster and Hevesey working in Copenhagen, and named after the ancient name of that city. But for the lacuna mentioned, it would have been discovered long ago, as scandium, gallium and germanium were, as it is a constant companion of the fairly abundant element zirconium, and not very difficult to separate from it. Its discovery was therefore rightly regarded as a very great triumph for the Bohr theory of the outer electronic structure of the successive elements in the Periodic Table.

It may here be of interest to recall that the first intimation of its existence immediately preceded the award at Stockholm of the 1922 Nobel Prize in Physics to Bohr. The following day he was engaged to give his Nobel Lecture, but kept his audience waiting a long time, as he was expecting a telegram from Copenhagen confirming the discovery, which however did not come. If it had, it would indeed have been a dramatic as well as an historic occasion. As it was, it furnished an amusing incident. For when at length the lecturer appeared, he was clearly in a state of great agitation. He began searching his pockets for his lecture notes, which he had omitted to bring, but pulled out instead his Nobel Prize in the form of pink Swedish bank-notes, which the audience, to their intense delight, instantly recognised as such, as pink is the colour of the notes of the highest denomination. As for the missing lecture-notes, that, as the Press remarked next day, did not seem to worry the lecturer, as the lecture, once started, went on for nearly two hours instead of one.

Rhenium is also now a thoroughly well-known element, having been discovered by X-ray spectrum analysis, by Noddack and his co-workers in 1925, in minute quantity in the ores of the platinum metals, and in the minerals tantalite and fergusonite. The technical extraction of it was at once undertaken by the firm of Siemens and Halske. It is the second heavier homologue of manganese, in place No. 75, and analogous in chemical nature to that element. The discovery of the first homologue, in place No. 43, was announced at the same time, and was, prematurely, given the name Masurium. But it is now believed not only not to have been found, but not to be a stable element. Recently, however, artificial unstable isotopes of it have been made, so that its chemistry is fairly well known. The same is believed to hold for the other vacant places, Nos. 61, 85 and 87, the discovery of all the elements in which has been repeatedly claimed and the missing elements named. But their stable existence seems to disobey an empirical generalisation, known as Mattauch's Rule, to be mentioned later. There are 14 existing rare-earth elements and, in this field, what Moseley's Law meant was movingly indicated by Professor G. Urbain, of Paris, one of the leading research workers in this tedious and exacting field, in an obituary tribute to its discoverer —"So the Law of Moseley confirmed in a few days the conclusions of my twenty years of patient work."

The Broader Aspects of the Nuclear Atomic Theory.

It is hardly necessary here to enter at all deeply into the original ideas arising out of the application of the quantum theory to the elucidation of the spectra of the elements which, in turn, resulted in the application of that theory to the detailed interpretation of the Periodic Law. As for the first, the work has little real application to the general chemical character of the elements and, even in spectroscopy, seems rather to have been largely the utilisation of the experimental spectroscopic evidence in the development of the quantum theory than vice versa, and to have little interest save to the spectroscopist. As for the second, much broader ideas than those originally postulated serve to reveal the general character of the Periodic Classification of the elements.

Essentially, the nuclear atom is divided into two regions, an inner and an outer, with normally an impenetrable frontier barrier between. Changes in the external electronic system are relatively easy to bring about and reverse, and such changes produce no corresponding change of the nucleus, but confer on the element its chemical character. Changes of the nucleus are transmutational in character and irreversible. When these occur, the external system instantly conforms to the new nucleus, and a new chemical element with different chemical character results. Apart from *force majeure*, only in one case, in the recently recognised "K-electron capture," is the frontier crossed, and, instead of the nucleus changing in a self-contained manner as in normal spontaneous atomic disintegration, it appears to be able to attract into itself an electron from the innermost K-ring, so reducing its atomic

number by unity, rather than itself expelling a positron, which would produce the same effect, but this may be a question of interpretation only.

Implicitly from the very beginning, as Sir W. Crookes realised, the Periodic Law epitomises an orderly evolution of the elements from one another, in which each element succeeds the preceding without its previous fundamental structure being thereby lost. In quantum language, the addition of each successive electron to the outer region, in passing from one element to the next, leaves unchanged the pre-existing electrons there in the same sort of quantum orbit (or, on the more recent view, stationary ring of wavelets), though, of course, the linear dimensions are shrunk proportionately to the square of the atomic numbers, as gone into in discussing Bohr's theoretical expression for the Rydberg constant. The quantum considerations that served to explain the series spectra of hydrogen serve to interpret, with suitable extensions, the whole Periodic Classification, of which, indeed, the hydrogen atom itself may be regarded as the embryo.

Instead of a single electron occupying, in the excited state of the atom, a number of quantum orbits integrally related to the normal, or No. I, orbit occupied when not excited, we have a number of electrons equal to the atomic number occupying different integrally related quantum orbits in the normal unexcited state. The term "regular-sequence elements" will be used to denote those other than what have been termed the interpolated elements and the rare-earth elements—in which the fundamental periodicity of 8 is changing to 18 and then to 32, for the two Short Periods, the two Long Periods, and the Longest Period, respectively. During this stage, according to Bohr, the number of electrons in the outermost shell is supposed to remain almost stationary, normally at two, though exceptionally some elements are given only one and palladium none, while the next inner shell is growing from 8 to 18. For the rare-earths it is the second inner shell that first grows from 18 to 32 and then the first inner shell from 8 to 18. For the regular sequence elements, it is only the electrons of the outermost shell that are detachable by, or play any part in, chemical changes, and these constitute the valency electrons, the transference of which from one atom to another results in chemical combination. The completed inner shells, apart from the exceptions enumerated, are all chemically inert, though, as we have already seen, electrons are detachable from them by electronic bombardment, when their restoration to the atomic structure results in the emission of an X-ray photon. The writer has often wondered whether, in time, there may not develop a sort of chemistry intermediate between ordinary and nuclear chemistry, in which these inner electrons, instead of the outer valency electrons, function to produce changes in matter intermediate between ordinary chemical changes and transmutation, but of that there is as yet no sign.

(To be continued.)

CHART OF IRON AND STEEL PRICES. Messrs. W. Richards and Sons, Limited, Britannia Foundry, Middlesbrough, have sent us a copy of the 26th annual issue of their "Chart of Iron and Steel Prices" from 1914 until the end of 1947. This gives, in graphical form and in clearly contrasting colours, the price levels, at the end of each quarter in each year, of crown quality bar iron, iron ship rivets, iron castings (ship's deck), steel ship plates, steel joists and angles, and No. 3 Cleveland brand pig iron. The bank rate is also shown on the chart, copies of which may be obtained from the firm at the above address.

OIL PROSPECTING IN GREAT BRITAIN.—The Anglo-Iranian Oil Company, Limited, Britannic House, Finsbury-circus, London, E.C.2, have sent us a brochure entitled *Petroleum in England*, which describes the work of prospecting for oil carried out, mainly in the Midlands, by their associates, the D'Arcy Exploration Company. Since the company commenced operations at Portsdown, in 1936, nearly a million feet of bores have been drilled; and, though the "strikes" have not been spectacular in their results, they have not been wholly unprofitable, some 300,000 tons of native oil having been contributed to British war needs.

THE ENGINEERING OUTLOOK.

VI.—COAL MACHINERY, STEAM-RAISING AND HEAVY ELECTRICAL PLANT.

THOSE sections of the engineering industry producing the plant, machinery and equipment required to modernise the coal-mining industry and to expand electrical generating capacity have received, during 1947, a growing degree of priority and Government assistance in meeting their requirements of materials, components and labour. The fuel crisis of last winter played an all-important part in this development, forcing the Government to take positive action in implementing their oft-asserted policy of "putting first things first" in their capital re-equipment programme. It was then decided at the highest level that nothing should be allowed to interfere with the production of coal-mining machinery and power-house equipment. As a first step, the industries concerned, together with certain other sections of engineering, the products of which were considered equally indispensable to the rehabilitation of the national economy, were granted special priorities* for supplies of finished steel. New responsibilities were placed on the Ministry of Supply to ensure that all should be done to enable manufacturers to obtain a regular and adequate supply of all necessary materials and components. The administrative machine set up for the purpose is an interesting example of an energetic attempt by the Government to achieve aims, universally acknowledged to be of the greatest importance to the country's survival, by a large measure of democratic planning and with a minimum of compulsion.

An examination in subsequent paragraphs of the progress made shows that success was hard won and, in some cases, only partial. The supply of components such as ball bearings, electric motors, precision chains, belting, etc., proved very difficult to secure, either in sufficient volume or in a regular flow. Inadequate labour supplies, however, have remained the hardest problem to solve, and it is significant that these sections of engineering have been classified as essential industries in the Ministry of Labour's circular to Employment Exchange managers for their "guidance" in placing labour under the Control of Engagements Order, which came into force last October. Engineering as a whole, however, is not listed as an essential industry. A clear admission of the seriousness of the labour situation was made in the Government's White Paper *Capital Investment in* 1948 (Cmd. 7268), where it is stated that an increase of 50 per cent. is required in the labour engaged on modernising coal mines, increasing electricity supplies, and in all general plant maintenance and repair for these industries from 12,127 in June, 1947, to 18,200 by June, 1948.

Before examining the varied steps taken by the Government to increase production, it is important to note that the production requirements adopted as targets may well prove inadequate if Britain is to play an effective part in the European Recovery Programme, and if these industries are to retain their traditional overseas markets or to capture markets previously dominated by Germany or Japan. Mr. Truman's message to Congress on January 7, 1948, made it quite clear that, in steel and machinery, the import needs of participating European countries would not be met, even if the Administration's proposals should pass through Congress unscathed. Steel supplies from the United States will amount to only 9·6 million tons between July, 1948, and June, 1949, and supplies of machinery also appear to be far below the level indicated in the Paris report of the Committee of European Co-operation; for example, import requirements from the United States for the four years 1948 to 1951, for coal-mining machinery, electric generators, oil-refining plant and steelworks plant, were estimated at some 1,475 million dols., of which it would appear that only about 900 million dols. is covered by the American proposals. The acceptance of the Marshall plan will almost inevitably involve an even more severe pruning of the British capital-investment programme, and this may inflict serious damage on British industrial recovery; yet it is generally agreed that the Paris targets, already revised at the instigation of the United States representative, were minimum requirements, without which no speedy European recovery can take place. The dilemma that the British Government will have to face, should the Truman offers fail to be ratified by Congress, will thus be most serious. It may well involve the diversion of output from home supplies of the very capital items urgently needed for British industrial re-equipment—even of items required for the fulfilment of the British undertakings in the Paris report.

Another most important result of increased British exports of capital equipment under the European Recovery Programme will be to reduce the already small proportion of output earmarked for Britain's regular customers in Empire and other export markets. It is inevitable that the future commitments of those engineering industries producing basic capital goods should be reviewed with a view to determining as far as possible the most desirable pattern of future exports. In this field, immediate priorities may clash with long-term interests, particularly those of manufacturers of heavy electrical and steam-raising plant. In an earlier article, it was pointed out that the Government's bilateral trading policy would probably involve supplying steel and capital equipment to countries which have elected to remain outside the Marshall plan, such as the Soviet Union, Poland, and other Eastern European states. These countries have suffered greatly from war devastation and are seeking capital goods to rehabilitate their economies in exchange for their food surpluses and timber, which Britain needs urgently. Any British failure to supply capital goods will not only prevent the conclusion of trade agreements (and lead to a worsening of the political situation) but also will speed up the development of competitive engineering industries in Eastern Europe—particularly in Czechoslovakia and in the eastern zone of Germany. On the other hand, high priorities for home developments, exports to Western Europe under the European Recovery Programme (much of which will remain largely unrequited) and to Eastern Europe under bilateral trading agreements (which may end abruptly if the political situation deteriorates) will leave little to supply traditional British markets in Empire countries and Latin America. Of these, hard-currency orders will doubtless receive priority and, in consequence, the British Dominions may be starved of most essential equipment.

If this means that they will be supplied by the United States, it must constitute a powerful argument against unrequited exports to Europe. The supposition is, however, that the United States will be unable to meet the demand from these quarters, as otherwise it would supply the greater proportion of the European needs under the European Recovery Programme; but there is some uneasiness among manufacturers concerning future exports, and Sir Claude Gibb, chairman of C. A. Parsons and Company, Limited, stated in July, 1947, the fears of his industry regarding future exports: "At the present time," he declared, "there is a desperate shortage overseas, as here, of capital goods. We could not meet more than a fraction of the shortage with our present output and working hours, and the needs are being met by other countries . . . In five to ten years' time . . . the capital goods markets will have been lost to Switzerland, the United States and Sweden, who will retain them. A capital goods market is not easily recovered. Once you install Swiss, Swedish or American plant as your first units in a power station or factory, you go on installing the same machines, spare parts and replacements."

This grave warning by a man who possesses unrivalled knowledge of his industry should not go unheeded, but should be interpreted as a plea for increased production; in fact, it means increased supplies of steel, components and labour. There is evidence that, during 1947, the Government realised the importance of such a step. In June, an announcement from the Ministry of Supply indicated that a special organisation had been set up to ensure,

* Other products included in the Prime Minister's priority list were the plant for gas undertakings; equipment for the coal-oil conversion programme; freight locomotives; coal wagons and rails for essential maintenance; and materials for atomic energy projects.

as far as possible, that manufacturers obtained all the necessary materials and components, to help them over difficulties with material supplies, labour and the location of any necessary component capacity, and to progress orders so that deliveries would be made in time. A special division was set up in the Ministry of Supply with three Directorates, the Directorate of Power Station Equipment, the Directorate of Mining Equipment, and the Directorate of Royal Engineer Equipment, a section of the latter dealing with the coal-oil conversion programme. In addition to the establishment of the Directorate of Power Station Equipment, the war-time Heavy Electrical Plant Committee was reconstituted under the chairmanship of the Minister of Supply. This committee comprises the turbo-alternator manufacturers and boiler-makers, together with representatives of the Government departments concerned, the Central Electricity Board, the Electricity Commissioners, and the electrical trades unions. In December, 1947, Mr. G. R. Strauss, the Minister of Supply, announced the setting up, in conjunction with the Ministry of Fuel and Power, of a Mining Equipment Advisory Council, constituted on similar lines, to assist the Mining Directorate in developing the production of coal-mining machinery. The Council will be composed of representatives of several Government departments, the manufacturers of the equipment, the Coal Board, and the mining and engineering trades unions. One of their main functions will be to consider demands for new mining equipment and

TABLE I.—*Deliveries of Coal Mining Machinery, 1944-47.** (Monthly averages or calendar months.)

	Coal Cutters, Numbers.	Power Loaders, Numbers.	Conveyors, Numbers.	Colliery Tubs and Mining Cars,† Tons.
1944	42	5	103	—
1945	45	8	124	—
1946 1st Qr. ..	53	10	164	—
2nd Qr. ..	70	9	169	—
3rd Qr. ..	61	9	160	—
4th Qr. ..	74	9	189	—
1947 January ..	63	6	122	3,000
February ..	62		156	3,500
March ..	77		171	4,000
April ..	75	10	195	5,370
May ..	73		201	6,600
June ..	103		191	5,204
July ..	67	9	214	4,556
August ..	39			4,614
September ..	100			4,669
October ..	83	—	212	5,379
November ..	68	—	242	4,856

* Deliveries for home use only; 1945-6 figures supplied by the Ministry of Fuel and Power.
† Carrying capacity; figures relating to pit-tub production exclude those made at collieries.

to determine which firms are available to carry out the orders which will be placed by the National Coal Board.

Such developments are new in Britain in peace time, and are designed to cope with a new situation brought about by the nationalisation of the mining, electricity and transport industries. The State henceforward becomes the chief customer of the industries supplying plant and machinery, and the committees or advisory councils set up for the purpose of discussing production and labour problems, the relation of demand to permanent capacity, the placing of orders, the percentage to be exported, etc., are of vital importance to both sides of the industries concerned. It is to be hoped that the deliberations of these bodies on the more important points of policy will be published, and that any important differences of opinion between manufacturers, trade-union representatives and the Government will be allowed to come up for public discussion. Unless this is done, the Government's position as a monopoly consumer may well eliminate the competitive character of the supplying industries and reshape their structure in a way that may be harmful both to the long-term interest of the manufacturers concerned and to the future prospects of British engineering. The following review of production progress in the industries concerned underlines the fact that the new organisation lacks powers to implement its policy and to carry out its terms of reference. Shortcomings, however, are very much an indictment of Government planning as a whole—the type of planning described in the first article of this series as "planning at half-cock on the basis of inadequate statistics." Engineering production planning is, indeed, a formidable task when planners do not know the capacity of the industries manufacturing components and ancillary equipment, and cannot effectively move labour for lack of housing and a wages policy (or effective direction measures).

The mining-machinery industry has been described as a collection of a large number of loose and unconnected units, and, although this is perhaps an exaggeration, any generalisation made to fit the industry will rarely fit all units concerned. The range of mining machinery is very wide and many concerns produce an even wider range of other products. Table I, herewith, shows the average monthly deliveries for coal cutters, power loaders, conveyors, and colliery tubs and mining cars. No production figures are available for other types of machines. From the table it is evident that the deliveries of conveyors have steadily increased, though a setback was incurred during the first quarter of 1947 owing to the fuel crisis. Deliveries of other types of machines have been maintained at a fairly high level during the second and third quarters of the year, though no spectacular increase has taken place.

By far the most pressing problems connected with production during 1947 have been concerned with the availability of components, and ancillary equipment. Even deliveries of steel have not always corresponded to allocations; for example, at June 30, 1947, of the steel allocated to four coal-face machinery firms for the period ending on that date, nearly a quarter was still undelivered. Some of the principal shortages were of ball bearings, belting for conveyors, and electric motors. The inability of the ball-bearing industry to meet the postwar demand led to the purchase of two million bearings in the United States in 1947. This was due to the increased demand arising from the Coal Board's decision to install underground conveyors on an unprecedented scale. Manufacturers have stated, however, that they expect to be able to meet the Board's requirements for ten million ball bearings during 1948. The shortage has delayed the installation of conveyors and has had a retarding effect on the coal-face machinery industry generally.

Conveyor-belting requirements have soared far above the capacity of the belting industry. Figures given by the Ministry of Supply show that the belting industry's target of 9·8 million feet for 1947 included 8·5 million feet for the coal-mining industry, a million feet for other industries, and 300,000 feet for export. The figure for the coal-mining industry showed a deficiency of two million feet, for which an order was placed in the United States. No delivery had been made by the end of the year, however, and the order was subsequently reduced by a million feet. There are hopeful signs that the British belting industry will be able to meet future requirements of the Coal Board and other industries, and that no further imports of belting will be required; although it is most unlikely that the spinning and weaving capacity for cotton duck will be able to keep pace with the expansion of the belting industry. In 1947, the Coal Board placed an order for 3,500 tons of cotton duck from the United States; over half this quantity had been received by the end of the year and the balance is expected early this year. It is probable that further imports of some 5,000 tons will be required to enable belting manufacturers to complete their 1948 programme. Coal Board belting requirements were estimated at about 13 million feet for 1948, rising to 16·5 million feet in 1951 and settling down thereafter to approximately 15·5 million feet per annum.

Certain types of electric motors were in even shorter supply than either ball bearings or conveyor belting. The total consumption of electric motors is unknown, since the Government cannot accurately measure the replacement demand of the industry. The total demand, however, must be considerable, since the number of motors installed in the mines increased from 55,555 at June 30, 1938, to 72,600 at June 30, 1946. The most acute shortage was of

TABLE II.—EXPORTS OF MINING MACHINERY OTHER THAN PORTABLE POWER TOOLS.*

	Tons.			£1,000.		
	Eleven-twelfths of Year 1938.	Eleven Months Ended November 30.		Eleven-twelfths of Year 1938.	Eleven Months Ended November 30.	
		1946.	1947.		1946.	1947.
Coal cutters	525	924	858	114	297	367
Winding machinery, steam and electric ..	3,270	1,922	2,020	265	283	348
Other types	19,665	9,490	10,375	1,731	1,499	1,663
Other types of machinery to :—						
British West Africa	1,906	2,720	2,640	189	246	248
Union of South Africa	4,348	1,174	1,203	551	319	242
British India	1,086	657	557	73	101	94
British Malaya	4,780	550	2,012	309	65	261
Canada	1,598	264	168	79	36	28
Other British countries	3,294	1,258	871	292	219	156
France	44	253	148	6	68	52
Other Foreign countries	2,519	2,614	2,776	232	445	582
Total, all types	23,460	12,336	13,253	2,110	2,079	2,378

* The figures for 1947 are not completely comparable with those for previous years.

TABLE III.—DELIVERIES OF BOILERS AND BOILER-HOUSE PLANT. (Monthly averages or calendar months.)

	Water-tube Boilers.		Shell Boilers.		Steam-raising Plant Accessories.	
	Total.	For Export.	Total.	For Export.	Total.	For Export.
1945 October	1,049	498	215	43	323	52
November						
December						
1946 January	1,268	557	302	89	358	56
February						
March						
April	1,539	640	303	95	410	78
May						
June	1,484	471	344	138	394	98
July	1,169	408	359	157	419	75
August	1,492	611	373	137	398	93
September	1,417	564	325	108	486	114
October	1,312	382	417	145	447	89
November	1,608	738	330	108	473	90
December	1,700	651	329	97	393	87
1947 January	863	333	234	73	308	68
February	1,129	461	312	98	418	95
March	1,264	283	352	136	462	76
April	1,549	730	361	118	508	92
May	1,223	368	385	118	610	119
June	1,724	573	426	131	560	141
July	1,561	527	372	138	581	145
August	1,663	569	537	218	677	164
September	2,162	882	521	176	759	168
October						

the smaller motors below 25 h.p., such as are used for conveyors, loaders, portable tools and for auxiliary ventilation. In 1946, there were 25,000 such motors, 11,000 of which were used for coal-cleaning and screening machinery at the pit-head and the remainder below ground. Towards the end of 1947, some improvement had taken place (mainly at the expense of demand from other sections of engineering) though local shortages persisted.

The labour position cannot be accurately assessed for want of reliable data. In December, the Ministry of Labour announced that it was about to apply for the release from the Forces of men formerly employed on the production of coal-mining machinery. Only fully skilled men, however, and apprentices who were in their final year when called up for the Forces, are eligible for release, and applications have not been made for men called up after the end of 1946. It is doubtful if the number of releases will eliminate the present shortage, although the Government's recent decision to limit the steel allocations to the shipbuilding industry may release enough shipbuilding labour to fill the vacancies notified by coal-mining machinery concerns in Scotland and the Tyneside area.

There have been several extensions to the capacity of the industry since the end of the war, some in the form of the acquisition of Government factories by individual manufacturers and others by additions to existing buildings. An acquisition of considerable importance to the industry was the purchase of a Ministry of Supply war-time factory at Workington, Cumberland, by the Distington Engineering Company, with floor space of 104,860 sq. ft. This is now used for the manufacture of mining machinery, under licence from the Goodman Manufacturing Company, of Chicago, as well as for mining cars and steel castings. Huwood Mining Machinery, Limited, have carried out extensions of 52,250 sq. ft. to their factory at Gateshead, and Anderson Boyes and Company have extended their factory at Motherwell, and at present occupy only about half of the 18 acres at their disposal. British Jeffrey-Diamond, Limited, Wakefield, acquired a new factory site of about 19 acres in 1946 and had a large twin-bay building in production by mid-1947. So far as is known, no other important increase in capacity is planned, and the coal-mining machinery industry is expected to be able to meet the Coal Board's requirements. At present, the industry as a whole is producing to the limit of its steel quota and it is probable that, by the time that steel supplies can be increased, the demand from the National Coal Board will be declining and it will be possible to devote more attention to export markets for coal-mining machinery and to other lines of engineering, in which many manufacturers are said to be interested.

Exports of mining machinery are controlled, licences being issued by the Ministry of Supply, and a minimum is being exported to retain the goodwill of overseas customers. Available figures, as given in the *Trade and Navigation Returns*, November, 1947, are shown in Table II, opposite. It will be seen that, in the 11 months ended November 30, 1947, exports totalled 13,253 tons, compared with 23,460 tons in the corresponding 11 months of 1938. The value of exports, however, was slightly higher in 1947 than in 1938—2·4*l.* million, as compared with 2·1*l.* million. The destination of all exports is not available, but those of the category defined as "other machinery" in the *Trade Returns* are shown to go mainly to British countries, large shipments being sent to British West Africa, the Union of South Africa and British Malaya. The amount of mining machinery and equipment which it has been possible to import during recent years has been comparatively small; in the first 11 months of 1947, the total value of imports was 317,525*l.* Under the European Recovery Programme, however, Britain is to get 18·8*l.* million worth of coal-mining machinery from July, 1948, to June, 1952, of which the largest proportion—8*l.* million—is to be delivered during the first year; but little is known of the types of machines which are to be sent out and how far these supplies will work in with those available from home sources.

The production of electricity generating plant dominates the activities of two large sections of heavy engineering, the boiler industry and the heavy electrical plant industry. In this field, the problem of inadequate production is more acute than in almost any other field of engineering, and many efforts are being made to increase production. Shortages of components—ball bearings, valves, gauges, etc.—are often delaying deliveries, and are a constant source of irritation to manufacturers. The shortage of steel, particularly of "electric sheet" steel (mild steel with a 4-per cent. silicon content) is one of the major causes of difficulty and delay in the supply of heavy electrical plant, and the shortage of tubes is a serious obstacle to increased production of water-tube boilers. The heavy demand from Middle East oil companies for pipeline tubing has resulted in a serious shortage of capacity for boiler tubes. There is also a very marked shortage of labour, particularly of skilled grades. The problem, however, is largely one of housing and accommodation, and any alleviation must be gradual. The Government have recognised the urgency of the labour problem, and steps are being taken both departmentally and by certain local authorities to provide additional accommodation.

In November, 1947, the Government took a very important step to accelerate the delivery of power-house equipment. The Ministry of Supply issued an Order (S.R. and O. No. 2386 of 1947) which requires the standardisation of heavy electrical plant for the Central Electricity Board's grid system. It is estimated that the effect of the Order will be to shorten the delivery dates of equipment by six to nine months. The new regulation standardises the production of steam-driven turbo-alternators of more than 10,000 kW at 30,000 kW and 60,000 kW, which will become the standard plant for large generating stations after 1949; the orders for the major items of plant to be installed during 1948 and 1949 having already been placed. The Minister, Mr. G. R. Strauss, explained that standardisation of turbo-alternators would not mean uniformity of detailed design; each manufacturer would continue to use his own particular pattern, provided that the sets produced conformed to the functional standard specified. The standardisation order was described as only a first step. The Ministry of Supply have decided that boiler drums can be standardised in diameter and thickness, as well as steam and water pipes. This will probably lead to similar measures in other components. It sets a precedent for other industries, such as the locomotive industry and the coal-mining industry, where considerable gains in productivity may be similarly obtained.

Sir John Greenly, chairman of Babcock and Wilcox, Limited, gave his views on the new Order at the 48th ordinary general meeting of the company, in August, 1947. After pointing out possible difficulties arising from supplies of ungraded coal, and stressing the importance of unhampered research and development, he went on to say: "Standardisation of steam generating plant is no easy task, even when supplies of good coal are available, and it is even more difficult in present circumstances. If, however, regular supplies of graded fuel of known calorific value were available, purchasers would be content during the next few years to accept types of steam-raising equipment of proved efficiency and design, and much could be done to increase production. This is no time for frills or foibles—neither is it a time to allow the best to be the enemy of the good. Utility, efficiency and economy should be the permanent considerations in design, but this does not mean that research and development should not be continued. Indeed, if, for a period, it is

TABLE IV.—DELIVERIES OF ELECTRICITY GENERATING PLANT 1946-7. (Monthly averages or calendar months).

—	Hydraulic Turbines.		Steam Turbo-alternators, 10,000 kW and over.		Steam Turbines, less than 10,000 kW.	
	Total.	For Export.	Total.	For Export.*	Total.	For Export.†
	Thousand B.H.P.		Thousand kW.			
1946—1st Qr.	10·2	10·2	51·7	—	19·6	—
2nd Qr.	12·9	12·9	76·7	—	11·8	—
3rd Qr.	14·0	14·0	40·8	—	12·4	—
4th Qr.	11·4	11·4	100·7	—	22·8	—
1947—January	42·0	42·0	60·0	30·0	9·7	6·7
February	11·5	11·5	55·0	25·0		
March	16·7	16·7	146·5	74·0		
April	—	—	40·0	40·0	15·5	11·4
May	—	—	52·5	40·0		
June	—	—	167·5	32·5		
July	4·9	4·9	80·0	18·8	—	—

* Of the total in 1946, 275,600 kW were for export. † Of the total in 1946, 160,700 kW were for export.

TABLE V.—EXPORTS OF BOILERS AND BOILER HOUSE PLANT.

—	Tons.			£1,000.		
	Eleven-twelfths of Year 1938.	Eleven Months Ended November 30,		Eleven-twelfths of Year 1938.	Eleven Months Ended November 30,	
		1946.	1947.		1946.	1947.
Water-tube Boilers, to :—						
Eire	4	545	928	1	63	102
Union of South Africa	6,520	2,374	3,582	424	208	486
British India	4,059	3,506	5,818	285	366	792
Australia	2,945	1,060	1,497	226	158	250
Other British countries	3,956	2,118	1,667	274	230	325
Brazil	583	972	863	30	125	130
Argentina	1,169	445	516	72	97	56
Other Foreign countries	10,906	4,157	4,468	822	459	651
Total	30,142	15,177	20,339	2,134	1,706	2,792
Other descriptions of boilers and boiler-house plant :—						
Locomotive type for stationary purposes	759	444	319	53	47	47
Lancashire and Cornish types	1,273	3,294	2,585	57	253	206
Other sorts, except water-tube	2,819	4,990	8,060	195	501	1,084
Economisers, feed-water heaters, and steam superheaters	6,207	4,374	9,486	341	537	1,298
Other boiler-house plant	10,106	13,181	31,505	760	2,070	4,991
Total	21,164	26,283	51,955	1,406	3,408	7,626
Total, all types	51,306	41,460	72,294	3,540	5,114	10,418
Analysis by Countries.						
Union of South Africa	2,830	2,740	2,534	195	327	336
British India	3,143	8,908	7,830	174	887	881
Australia	1,559	711	1,424	122	131	235
Other British countries	4,843	2,783	4,110	301	330	631
Soviet Union	204	3,073	24,912	35	780	3,873
Iraq	20	712	880	2	93	105
Other Foreign countries	8,565	7,356	10,265	557	860	1,565

desirable to keep to present designs, it is of all the more importance that research should be pushed forward in anticipation of more normal times in the future."

The Central Electricity Board's requirements for plant in the period 1947-54 have been reviewed several times during 1947. The Board's original programme envisaged an increase in generating capacity of no less than 70 per cent., to be achieved in a period of seven years, to overcome arrears of expansion of generating capacity and the accumulation of replacement orders during the war years. That part of the programme approved by the Electricity Commission provided for a very large increase in the output capacity of new plant installed each year, which was to rise from 997,000 kW in 1947 to 2,167,000 kW in 1951. In July, these forecasts were revised; in the light of difficulties due to problems of reconversion and delays in plant delivery, it was suggested that the output capacity of new plant installations would be reduced in the earlier years, to 518,000 kW in 1947 and 757,000 kW in 1948. In consequence, the new output capacity estimated as coming forward in the later years rose to 2,645,000 kW in 1951. In September, the very serious gap existing between generating capacity and demand caused the position to be reviewed again, and the projected rate of delivery was advanced so as to increase the new output capacity installed in 1948 to 1,150,000 kW, thereby reducing arrears in later years. The output capacity of plant due to come into service in 1951 thus became 2,000,000 kW. In December, the Government's revision of the capital investment programme provided new targets. It was pointed out that the Board's estimates included a surplus of generating capacity for the later years, and that this could no longer be afforded; although, in normal circumstances, it would have been most desirable in order to provide a margin over the great increase in the estimated peak demand. The targets for 1950 and 1951 were thus reduced from 2,000,000 kW to 1,500,000 kW.

The White Paper (Cmd. 7268) commented thus on the reasons which prompted the Government to risk a continuation of load shedding at peak periods: "The decisive factor in reaching the present decision was the enormous quantity of steel required for the original programme—no less than 279,000 tons in 1948 rising to 332,000 tons in 1949, to which must be added corresponding building steel requirements of 125,000 tons and 165,000 tons, respectively. The reduction in steel requirements following this decision will be 27,000 tons in 1948 (from plant being made for installation in 1950) and larger quantities later." The revised targets—ignoring any possible contribution from plant over 25 years old—will probably leave a generating plant deficit of 824,000 kW during the winter 1951-52.

Doubts have been expressed about the ability of the turbo-generator makers to reach the production targets set by the Central Electricity Board without greatly damaging the long-term export prospects of those industries. Sir John Greenly, in the speech already quoted, said that ". . . it is little use producing an excess of power plant if there is not sufficient coal available for its use. Neither is there any value in producing an excess of electric power if the secondary industries of the country are to be kept short of steam-raising equipment or of coal for their processing work. A further vital consideration is the question of exports; if we starve our exports by being too prodigal over production for home use, we shall lose our export markets, and if these are once lost it may take us years to recover them—if, indeed, they can be recovered at all." This plea for preserving as much normality as possible in the balance of production and the pattern of sales is clear evidence that Sir John feared that the Government's insistence on power-plant equipment for home use, to the exclusion of practically everything else, constituted a danger to the long-term interests of the industry.

Delivery figures for boilers and boiler-house plant, showing those earmarked for export, are given in Table III, on page 124, and for electricity generating plant in Table IV, on page 125; the data in both tables are taken from the *Monthly Digest of Statistics*, December, 1947. The output of water-tube boilers showed a remarkable improvement during the second half of 1947, the value of deliveries during the third quarter exceeding the corresponding figure in 1946 by nearly a fifth. In October, the value of deliveries was at the annual rate of 25·9*l.* million a year. Even if this rate of deliveries were maintained during December, however, it is unlikely that total deliveries were greater in 1947 than they were in 1946—16·9*l.* million—owing to the considerable loss of output incurred during the fuel crisis. Deliveries of turbo-alternators (of 10,000 kW or over) were substantially better in 1947 than in 1946, when they totalled less than 810,000 kW. The annual rate of deliveries during the first seven months of 1947 was 1,030,000 kW.

TABLE VI.—EXPORTS OF ELECTRICAL MACHINERY.

	Tons.			£1,000.		
	Eleven-twelfths of Year 1938.	Eleven Months Ended November 30,		Eleven-twelfths of Year 1938.	Eleven Months Ended November 30,	
		1946.	1947.		1946.	1947.
Generators :—						
Complete*						
Not exceeding 200 kW	1,980	2,135	4,361	419	719	1,452
Exceeding 200 kW	7,453	8,032	11,135	1,310	2,220	3,770
Parts	—	1,568	5,194	—	477	1,836
Total	9,433	11,735	20,690	1,729	3,416	7,058
Transformers for lighting, heating and power, including coils†	9,619	8,643	15,894	1,114	1,808	3,120
Rectifiers for power-houses	207	230	430	38	105	195
Switchgear and switchboards (other than telegraph and telephone)	8,929	6,515	10,672	2,030	2,380	4,084
Total	18,755	15,388	26,996	3,182	4,293	7,399
Steam Turbines	1,256	1,608	2,352	420	670	1,334
Total, all types	29,444	28,731	50,738	5,331	8,379	15,791

* Includes parts in 1938.

† Includes converters in 1938.

Exports of power plant equipment, as given in the *Trade and Navigation Returns*, November, 1947, are shown in Table V (Boilers), on page 125, and Table VI (Heavy Electrical Machinery), on this page. The deliveries earmarked for export in 1947 averaged 42 per cent. of the total deliveries of turbo-alternators (first seven months) and of water-tube boilers, 36 per cent. The destination of exports of water-tube boilers was mainly British countries, which accounted for 70 per cent. of the total, British India being the principal market, with 28 per cent., followed by the Union of South Africa with 17 per cent. Of the foreign markets, Brazil and the Argentine were the most important, together accounting for about 7 per cent. of the total. British India was also the principal market for generators, followed by Russia and South Africa. Russia was the principal foreign recipient of British heavy electrical plant, and is likely to remain in this position if the recent trade agreement is extended during 1948.

It should be noted that deliveries earmarked for export do not correspond to actual export shipments; for example, the *Trade Returns* figure for water-tube boiler exports for the first 11 months of 1947 was 2·8*l.* million, compared with 5·4*l.* million earmarked for export during the first ten months of the year. In certain cases, this may be due to the shortage of transport and shipping facilities, and in others to the fact that a large proportion of "finished" products are considered "delivered" by manufacturers, although they are waiting for some essential component or accessory. Finally, the discrepancy between the figures for goods exported and goods earmarked for export may be accounted for, in part, by the failure of a proportion of those goods earmarked for export to find their way overseas.

Costs of production have become important factors in overseas sales, and certain manufacturers have expressed fears that the seller's market may end sooner than was expected. This seems hardly possible during the next five years, in the light of available information concerning overseas requirements, unless the purchasing power of British and foreign countries is weakened by shortages of sterling, which are bound to be aggravated by cuts in British imports. Sir Claude Gibb, previously quoted, made the following statement concerning exports in July, 1947: "My company have adequate export orders for electrical generating plant—even pre-war, 60 per cent. of our output was for overseas; but a recent example of competition is an indication of the shape of things to come. Tendering for a turbo-alternator to a European country which is a food exporter, my company's price of 123,000*l.* was the lowest British price, and lower than Swiss or Swedish tenders, but the order was placed with Czechoslovakia at 68,000*l.* Obviously, that company wanted work badly, but we also wanted that order and had quoted a cut price. Can the Czechs cover their costs at that low price? I believe they can—their coal and steel costs were half ours pre-war, and their workmen are highly skilled and industrious. I give this example as a taste of the competition coming before long when the present sellers' market ends."

Leading concerns in the industry have been most active during the past year in taking steps to increase facilities for research and development work. In November, Mr. Harold Wilson, President of the Board of Trade, opened the Nelson Research Laboratories of the English Electric Company, at Stafford. The laboratories are divided into ten sections, each of which is engaged upon a particular aspect of electrical engineering. One of the most interesting ventures is in the field of nuclear-physics, where the company's staff are co-operating with the Government Research Departments in research on the future use of nuclear energy for application to power, medical use, and other fields.

In September, the application of the gas turbine was carried a stage farther by the installation of the first engine of this type in a naval vessel. A Metropolitan-Vickers gas turbine was fitted in H.M. Motor Gunboat 2009, and the Admiralty are understood to be planning a larger installation for an escort vessel. The challenge of the gas turbine has not yet been felt seriously so far as the larger power stations are concerned, but much attention has been give to its development by manufacturers in this country. It is probable that, if means of using solid fuel could be found, and if metallurgical advances permitted the employment of higher initial temperatures, the gas turbine might achieve a high degree of efficiency and be adopted as a prime mover for the generation of electricity. It is unlikely, however, that such a development will take place during the next decade.

The chief problem of the industries reviewed in this article will remain throughout 1948 one of production, and the chief obstacle to maximum production will almost certainly be shortage of steel and engineering components. The Government, through their newly established administrative machinery, can help industry to overcome many of its difficulties and, if coal supplies continue to be adequate, it is hoped that deliveries in 1948 will reach new high levels.

ALMANACS AND CALENDARS.—We have received a tear-off wall calendar, having two months to a page, from Messrs. Ruston and Hornsby, Limited, Sheaf Iron Works, Lincoln; and a large monthly tear-off wall calendar from Messrs. Harland and Wolff, Limited, Queen's Island, Belfast.

AIRCRAFT POWER PLANT ENGINEERING.*

By FRANK NIXON, B.Sc., F.R.Ae.S., M.S.A.E.

THE greatest single contribution made in recent years by aero-engine manufacturers to the safety and reliability of aircraft, has been by their adoption of responsibility for the engine installation as a whole. This development has been peculiar to Great Britain, and it has led to the evolution of the self-contained power plant, which comprises the engine itself, its mounting, the cooling and oil systems, the engine controls, the engine-driven accessories, and the cowling. It is supplied to the aircraft builder ready for immediate installation, which requires merely the insertion of four pick-up bolts and the connection of a small number of controls, pipes, and cables. Installation and removal from the aircraft can be effected in a few minutes. The object of the paper is to review the work which has been done, and the success already achieved, with Merlin-engined power plants. This work is now being extended to cover the installation of gas-turbine engines such as the Nene and the Dart, which have already been seen operating in the Lancastrian.

Power plants are the outcome of a scheme which was initiated by the British Air Ministry in 1937, to prepare, for all the engines then available, designs of power plants which would be interchangeable with each other. The scheme was intended to safeguard output in the event of a given type of engine ceasing to be available. Details were worked out by a Committee of the Society of British Aircraft Constructors during 1938. Standardised arrangements of controls and bulkhead were laid down, and complete installational interchangeability between liquid-cooled and air-cooled engines of similar power was achieved. Fortunately (by reason of the wide dispersal and duplication of production facilities), it was not necessary to apply the scheme during the war, and power plant designers were able to introduce more flexibility into their designs than had been possible in the original layout. At the same time the period required to change a power plant in an aircraft was reduced from hours to minutes.

Until just before the war, engines had been installed by the aircraft manufacturers, with the single exception of a power plant which was built by the Engine Division of the Bristol Aeroplane Company in 1924, for the Jupiter VI engine in the Brandon aircraft. Engine firms, however, had been interesting themselves for some time in the problems of installation as affecting their engines and had therefore had some preparation for the task of producing complete power plants. During the war the Bristol and Rolls-Royce companies produced power plants in large numbers for such varied aircraft as the Master, Wellington, Halifax, Stirling, Lancaster, Firefly, Shetland, Whitley, etc.

The great value of the scheme is well illustrated by an interesting example. A power plant had been designed by Rolls-Royce around the Merlin XX engine for the Bristol Beaufighter aircraft. A. V. Roe, Limited, had designed the Manchester, a twin-engined bomber with two Rolls-Royce Vulture engines. It so happened that production of the Vulture engine was not so fully advanced as that of the Merlin, which was already being made in large numbers for fighters such as the Hurricane and the Spitfire, and in order to take advantage of this, it was decided to alter the wings of the Manchester to take four Merlins instead of two Vultures. Speed was essential, and Rolls-Royce offered to Avro the existing design of Beaufighter power plant. Only small changes were necessary to accommodate the undercarriage in the inboard nacelles, and to enable Avro to meet the required programme, Rolls Royce undertook to supply the complete power plants, ready for fixing to the wing nacelles. The company's efforts were by now fully absorbed by the production of Merlin engines, and accordingly the aid of automobile and automobile body companies was enlisted. Morris Motors, Limited, M.G. Cars, Limited, Morris Pressings, Limited, Briggs Motor Bodies, Limited, Alvis, Limited, and a host of smaller firms began the production of parts and the assembly of complete power plants, and so was born the Lancaster, which played such a notable and vital part in the war.

More than 35,000 Merlin power plants were produced in England during the war, the majority of them for Lancasters. In addition, more than 2,000 were built by Victory Aircraft, Limited, in Toronto, using the Packard-built Merlin engines for Lancasters built also by Victory. Also during the war, a Griffon-engined power plant was designed, and produced (by Sunbeam-Talbot, Limited) for the Fairey Firefly aircraft, a single-engined torpedo-bomber for the Fleet Air Arm. Towards the end of the war, keeping pace with aircraft developments, power plants with engines having two-stage superchargers were produced for the Avro Lincoln, while the past two years have seen much activity on civil versions of Lancaster and Lincoln power plants for the Avro York and Tudor aircraft. Resembling the Tudor power plant closely is that for the Canadian-built Douglas D.C.4.M. North Star aircraft (Fig. 3, page 132), which is playing a prominent part on Empire air routes, having already made more than 600 crossings of the North Atlantic.

Although each of these power plants has had to establish itself in the face of keen opposition, this last is of especial interest, as not only does it mark the entry of a liquid-cooled engine into the civil airline field hitherto powered exclusively by American radial air-cooled engines, but it was chosen having in mind the extremely arduous conditions encountered, which include the North Atlantic route, where ability to surmount icing conditions (at altitudes up to 25,000 ft.) is of great value, as well as the Montreal-Vancouver run, on which the Rocky Mountains have to be traversed.

A noteworthy feature of all Rolls-Royce power plants is the extent to which the various functions have been brought under automatic control and servo operation. In the North Star power plant, for example, there are automatic controls for coolant temperature and pressure, oil temperature, mixture temperature and fire detection. Electric actuators under automatic control operate the main and auxiliary cooling flaps and the hot-air intake selector, while solenoids operate the slow-running cut-off and the supercharger gear-change mechanism. Other power plants, such as the Tudor, use electro-pneumatic rams instead of electric actuators. Thus the pilot is relieved of the onerous duties of controlling these functions of engine and power plant operation. At the same time it is possible to dispense with a flight engineer and reap the financial benefit of carrying one additional passenger, while maximum performance of the installation is ensured by eliminating the human elements.

Whether the engine installation be the work of the aircraft designer or the engine designer, the basic requirements are the same. In the author's opinion, the fundamental requirements of the engine installation, in order of importance, are: 1. Safety—ensuring freedom from accidents. 2. Reliability—ensuring freedom from unscheduled delays. 3. Performance—to achieve maximum speed for minimum drag, weight, and fuel consumption. 4. Long life—for economy of operation. 5. Ease of servicing—for economy of operation and to reduce ground maintenance time, thus giving rapid turn-around and improving utilisation. 6. Interchangeability—for rapid replacement. 7. Repairability—for economy of operation. 8. Ease of production—necessary for large scale output. 9. Low cost. The order shown is primarily that for power plants for civil-airline operation. For military aircraft the first three desiderata would remain, but interchangeability and ease of production might conceivably come before long life, ease of servicing and repairability. It is interesting to note how with the establishment of aerodynamics as an exact science it is mechanical design which now assumes the preponderant share of the desiderata set forth above.

In common with all aircraft engine installations the power plant consists of an assembly of components which can be put into one of two groups: 1. Mechanical —comprising those units the design and manufacture of which follows "engine-engineering" lines, *i.e.*, of precision-machining, gauging, accurate assembly and functional testing. It includes thermostatic controls, pressure-control valves, servo-actuators, machined fittings, etc. 2. Sheet metal, etc.—comprising main and subsidiary mounting structures, cowling, header tank, coolant radiators, oil cooler, exhaust systems, etc., the manufacture of which follows sheet-metal practice of press-forming, riveting, welding, brazing and soldering.

The great majority of the items in the first group are manufactured by specialist firms who supply the aircraft industry as a whole. Before the advent of the power plant, however, there had been no rationalisation of types of unit, or controlled development. Neither had these firms imposed upon them the stringent standards of acceptance customary with aircraft engines.

Realising that if the development of their aero engines was to proceed on sound lines, it would be necessary to know more about their behaviour in flight, Rolls-Royce set up an experimental flight test section at Hucknall in 1934. Starting with one hangar, three Service aircraft, and a small technical and flight staff it grew in the next ten years to a fleet of 48 aircraft of all types, from the fastest fighters to the largest four-engined bombers, with a personnel of 1,500.

This combining of the engine and installation problems has been of inestimable value. A sound basis had already been established, and during the war and since, it has been broadened and deepened, and research and development facilities have been continuously augmented. When a new aircraft type is under consideration, the first prototype engine installation is often designed, built and flown at Hucknall, the finally developed arrangement being handed over to the aircraft designer when all problems have been solved and the performance raised to the highest pitch.

Thus, quite apart from the development of power plants, which is the main theme of this paper, much work was done on the Spitfire, Mustang, Mosquito, and other aircraft which contributed a great deal to the considerable increases in performance which were obtained. As an illustration of the range of the problems arising during the war years, engine manifold pressure increased from 6·25 to 30 lb. per square inch; the capacity of the Merlin from 1,050 to 2,050 brake horse-power; speeds of fighter aircraft from 350 to 440 m.h.p.; and service ceilings from 32,000 ft. to 45,000 ft. In addition, since the war, the life of the power plant between overhauls has been increased from 400 hours to over 2,000 hours.

The establishment at Hucknall functions as a self-contained unit, covering all stages from project design, through project research and development, prototype design and manufacture, rig testing, hangar testing and flight testing, to initial production of the final design. Situated a few miles away, at Ilkeston (Fig. 4, page 132), there is a production department where bulk production follows on initial production at Hucknall. There is an airfield having a runway of 2,000 yards, which is adequate for aircraft having an all-up weight of 80,000 lb. There is a small wind tunnel for the exploration of the design of ducts, air intakes, nacelle shapes, performance tests on elements of radiators, oil coolers, etc., and a larger one, 5 ft. by 7 ft. and 100-m.p.h. wind speed, for tests on scale models of complete aircraft, nacelles, cooling ducts, air intake ducts, etc. A general view of the larger tunnel is given in Fig. 1, page 128.

The rig shops section in the project department is one of the most complete of its kind. To mention only a few of the rigs there are those on which it is possible to simulate the complete cooling system, the complete oil system, and the complete fuel system, of a wide variety of installational arrangements. Altitude effects (up to 60,000 ft.) on the various systems, and low-temperature effects on components and materials, can be explored. There are vibrating machines to test components varying in size from radiators to small control units. In addition, there are test rigs for every variety of automatic control, actuators, valves, etc., used on the power plants. An interesting rig is that shown in Fig. 5, page 132, for conducting static tests on engine mountings. It is perhaps unique in being able to apply, simultaneously, all eight leads, namely, torque, thrust, vertical, lateral, and fore and aft inertia, pitching, yawing, and rolling couples.

In addition to the extensive flight-testing programme, covering both research and endurance flying, fire-extinguishing tests on complete aircraft are carried out. These latter check the ability of the fire-extinguishing system to cope with fires deliberately lighted and fed by oil and petrol from an outside source. Arrangements have also been made with the British and Canadian Governments to carry out trials in Canada, by means of which valuable information regarding operation at low temperatures has been gained. During the war the emphasis was naturally on performance and while this has in no way been diminished, much more regard is now paid to reliability and long life.

With the lowering of production since the end of the war, it became possible to begin to do what had long been desired. With certain civil types, a proof run is carried out on every power plant produced, to ensure that all systems and controls are functioning satisfactorily, so that the power plant can be installed into the aircraft with every assurance that the engine and its services will function immediately. For this purpose special silenced test hangars as illustrated in Fig. 6, page 132, have been designed. The complete power plant is mounted, with its airscrew on a "wing" of streamline section, which is attached resiliently to the walls of the test house. The nacelle structure aft of the attachment points on the bulkhead of the power plant closely resembles that used in the aircraft, so that the vibration characteristics, and the slipstream effects, are similar to those likely to arise in flight. For additional cooling, a fan driven by an electric motor is installed ahead of the power plant. The "wing" may be inclined upwards or downwards to simulate climbing and diving conditions. The controls, pipes, cables, etc., are led from their normal positions on the bulkhead through a tunnel inside the wing and through the wall, to a test panel in the cabin.

One test hangar is fully employed in carrying out type tests and development tests of long duration. Experience has established a close relationship between the behaviour of power plant components on hangar test and on flight test, and over 5,000 hours of development testing are carried out each year. During the whole of the test, the power plant cowling is not removed, and all the engine controls and accessories are used frequently.

Although, for the most part, the controls and actuators

* Paper read before the Association Française des Ingénieurs et Techniciens de l'Aéronautique on December 10, 1947. Abridged.

AIRCRAFT POWER PLANT ENGINEERING.

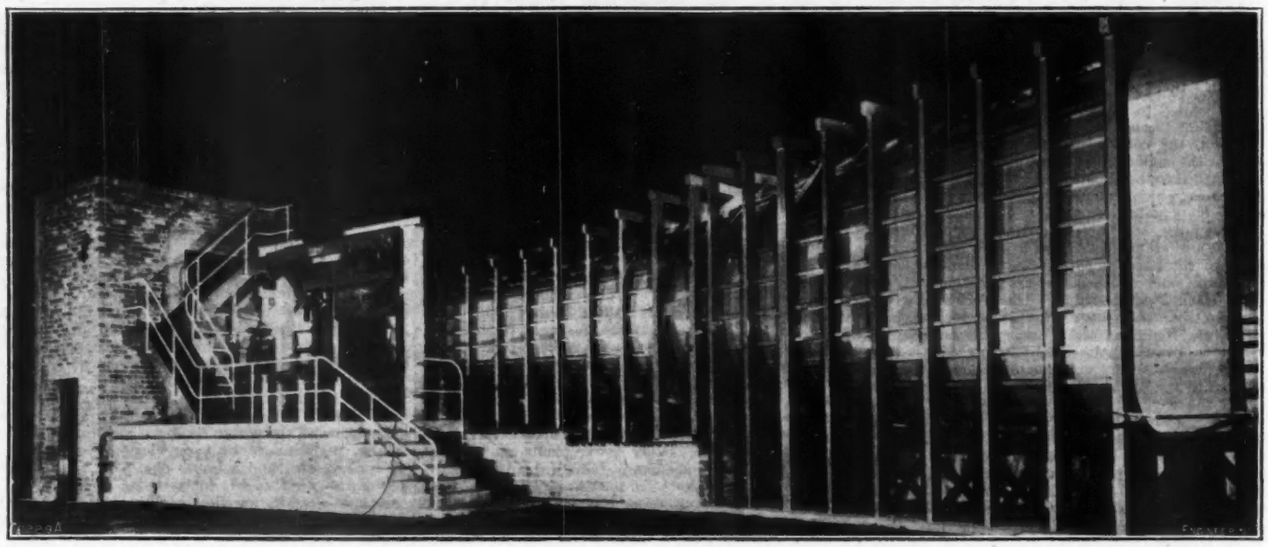


Fig. 1. 7-Ft. by 5-Ft. Wind Tunnel at Hucknall Works.

are designed and made on sound lines, and are fully inspected and tested by their manufacturers, the imposition of an additional functional test on receipt by Rolls Royce has been found to have considerable value. With sheet-metal components there was throughout the whole aviation industry before and during the war a great deal of petty unserviceability, "unscheduled delays" and sometimes major failures, due to defects in cowlings, oil coolers, radiators, and the like. Work to raise the quality of these items was initiated about four years ago.

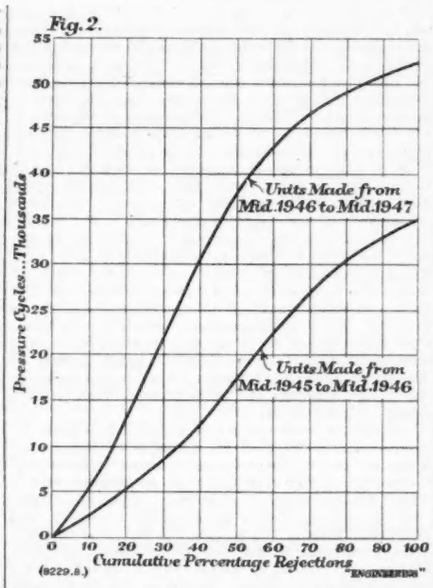
No better example can be taken of the way in which our efforts are applied, and of the results achieved, than the oil cooler and the coolant radiators. The work was begun at Hucknall in 1944, and very quickly the services of Rolls Royce were enlisted by the Ministry of Aircraft Production to deal with the oil coolers of air-cooled engines, which were probably the most unreliable units of any in the latter years of the war. This work greatly extended our knowledge and assisted considerably in arriving at a speedy improvement. Oil coolers and radiators were built originally on automobile lines, but with little regard to the duties imposed by aircraft operation, where the temperatures and pressures are a good deal higher. Until three years ago the production acceptance test consisted merely of two cold static-pressure tests and a heating to operating temperature without pressure. Even this test rejected a high proportion of the units produced and it is small wonder that, with their multiplicity of hidden and hand-made joints, these components gave trouble in service.

Up to the present time our coolant radiators and intercooler radiators have been of the secondary surface type, having a matrix of flattened copper tubes, 0·006 in. thick and fins 0·004 in. thick, or tubes and corrugations, which is assembled and then completely dipped in a bath of molten lead-tin solder. Sheet brass tanks, suitably baffled and stiffened, and provided with inlet and outlet connections, are soft-soldered by hand to the matrix tube plates, and fairings, mounting brackets, and supports are also hand-soldered to the whole assembly. Secondary surface oil coolers are of similar construction, but the honeycomb oil coolers which are more widely used follow more familiar lines. The jacketed casing is made of a shape to suit the space available, from silver-soldered and riveted sheet-brass pressings. The honeycomb matrices of hexagon-ended circular section copper tubes, 0·005 in. thick, are assembled into the casings by hand soldering.

Examination of several hundred failures during the war, both from the R.A.F. and from breakdown tests, has enabled certain definite conclusions to be drawn :—(1) The great majority of the failures occur in the soldered joints, and particularly in those made by hand. (2) In no case yet has a soundly-made joint been found to have failed. Structurally, then, the designs are, on the whole, satisfactory ; the ultimate life of a properly-soldered joint has not yet been reached, and it remains to ensure that the desired standard of joint is maintained consistently.

The joints, of course, cannot be taken apart for examination, and special methods have had to be developed for proving them. X-rays can be of little assistance since the cross-sections are too massive, and there is too much overlapping, for X-ray photographs to be intelligible. Everything possible is done in the assembly stages to ensure that the operator is achieving the best result. In addition, there is a constant search after the most suitable form of proof testing to eliminate unsatisfactory components. The ideal proof test must reject defective units while not diminishing the life of sound ones ; its indications of unsoundness must be clear beyond all doubt ; it should simulate service conditions as far as possible ; and it should be quick and cheap to apply.

Fig. 2.



The most satisfactory production acceptance test has been found to comprise 5,000 cycles of pressure, varying from zero to 10 per cent. above the maximum working pressure, at 150 deg. C. This follows a test laid down by the United States Army-Navy authorities during the war, but is much more extensively applied, while the cost of operation has been reduced by increasing the speed from six per minute to at least 40 per minute, and in some cases up to 150 per minute. At the same time the detection of leaks has been made more certain by the use of a fluorescent comepound in the test fluid.

In parallel with these production acceptance tests new type approval tests have been laid down which call for 50,000 pressure cycles ; a static-pressure test of twice the maximum working pressure without a serious permanent set ; and a series of vibration tests combined with pressure cycles. These new tests have been most effective in improving the quality of these components, as shown by the cumulative defect curves in Fig. 2, herewith. It is interesting to observe that in the majority of cases the improvement has been achieved without design change, and with very little alteration in shop practice, but is almost entirely due to an awareness of his responsibilities by the operator, and a revival of the old craftsman spirit.

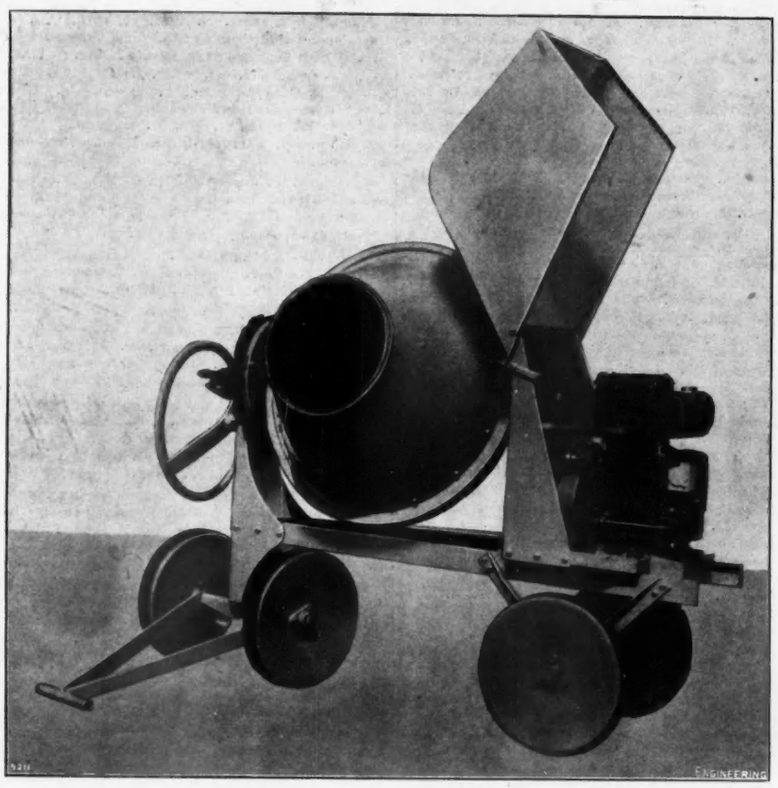
Similar work has been proceeding with header tanks, where the adoption of X-rays for the examination of soldered joints has been possible and has resulted in a like improvement. An instrument has also been developed which checks the thickness of the thin pressings which form the tank, by measuring the potential drop between contact points which are applied to the outside of the component. With parts such as cowlings, exhaust manifolds, and engine mountings, which involve torch welding and some riveting, quality is maintained by carrying out check tests which may involve the sectioning and destruction of the unit, on a percentage which varies with the results obtained. The result of all this has been a considerable increase in life of power plants between overhauls, and a large reduction in maintenance and replacement costs. For example, the overhaul life of the Lancaster tropical power plant has been raised from 400 to 2,400 hours and the North Star power plants are guaranteed against failure for 2,000 hours.

Although the engine-built power plant owes its inception to considerations of wartime strategy, it has been found to possess important advantages over the installation of the engine as a separate unit by the aircraft builder, as much in the civil as in the military field. The engine builder forms a common pool of knowledge and experience of the installation of his engine in a wide variety of aircraft, so that the standard of design and development will always be higher than the average of installations designed by a number of independent aircraft companies. There is considerable economy of overall effort, in that the design, development, tooling, provisioning, manufacture, inspection and testing are carried out by one organisation, thereby avoiding multiplication of staff and equipment. By the same token it is possible to install equipment for development and research which individual aircraft manufacturers would be unable to justify. The intimate contact between the engine and installation divisions of an engine company produces a closer mutual appreciation of the common problems, so that engines can be designed from the outset with the needs of the installation in mind. The aircraft designer is relieved of all the worry of the power plant installation during his preoccupation with the design and development of the prototype aircraft. Similarly, the airline operator is relieved of the onus of maintaining contact with a large number of suppliers of such power plant components as cowlings, radiators, oil coolers, header tanks, actuators, controls and safety devices, fire-extinguishing equipment, pipes, cables, etc.

This interest and activity in installation matters by engine people has been more than justified by the

CONCRETE-MIXING MACHINE.

MESSRS. STOTHERT AND PITT, LIMITED, BATH.



results, and although it is not permitted to reveal the details, it may be said that before the piston engine is supplanted by the turbine engine we shall see power plants of lower drag, lower specific weight, and longer life than even the present ones, with new techniques of production adopted to reduce the dependence upon the individual operator.

The experience gained is available for application to the installation of gas-turbine engines, which is perhaps more intimately bound up with the design and layout of the aircraft than is that of the piston engine. It is interesting to note that in the beginning the turbine engines were handed over to the aircraft manufacturer to install himself. Having enjoyed and appreciated the advantages of engine-built power plants, however, aircraft manufacturers have demanded that the installations of gas-turbine engines should be developed by the engine builder and as one consequence of this we have already seen the Nene and the Dort engines installed in the Lancastrian aircraft by Rolls Royce. Basically, the problems and desiderata are the same as those which have been described in the paper, and the benefits of the organisation and experience which have been built up on piston engines during the war years, are equally at the disposal of this new development, which for the next few years will provide a spur for the piston-engined power plants which have been the main subject of this lecture.

MODERN RAILWAY TURNTABLES.—To enable larger locomotives to be turned, modern turntables of increased size are to be installed on the London Midland Region of British Railways at Belle Vue, Manchester (57 ft.), Bournville, near Birmingham (57 ft.), and Llandovery, Carmarthenshire (65 ft.).

INSTITUTE OF FUEL BUILDING FUND.—In summarising the annual report of the Institute of Fuel, on page 411 of our 163rd volume (1947), we noted that a Building Fund had been started to purchase the new premises at 18, Devonshire-street, London, W.1, into which the Institute's headquarters had been recently moved; the sum required was 25,000*l*. We now learn from the secretary, Mr. R. W. Reynolds-Davies, that the amount received to date is nearly 19,000*l*. Sir Ernest Smith, C.B.E., is chairman of the appeal committee.

CONCRETE-MIXING MACHINE.

THE concrete mixer illustrated on this page is a general-purpose machine designed to meet the requirements of builders and contractors. It is manufactured by Messrs. Stothert and Pitt Limited, Bath, and conforms to British Standard Specification No. 1305 of 1946, having an unmixed-batch capacity of 5 cub. ft. and a mixed-batch capacity of 3½ cub. ft. The machine is of strong but simple construction, the frame being made from steel channel-section members while the uprights are steel pressings. It is usually driven by either a Lister 1½-h.p. D-type water-cooled petrol engine or a Petter A-type air-cooled petrol engine, but a petrol-paraffin engine, an electric motor, or pulleys for belt drive can be fitted if desired. The machine illustrated is fitted with a Lister engine, and it will be noted that the engine is provided with a weatherproof cover which can be raised as shown, a safety catch being fitted so that it may be locked in the raised position. The drive from the engine is transmitted to the driving shaft through a roller chain, the tension in the chain being regulated by a spring-loaded jockey sprocket. The driven sprocket is visible in the illustration, but when in use the sprockets and chain are covered by a detachable guard which is not shown. The drive from the shaft to the drum is through bevel gearing in the usual manner, the bearings in the transmission being of the roller type. The drum is supported by a tubular-steel cradle and the drum gear-ring is enclosed by a guard. The tilting mechanism also is totally enclosed, and the tilting gear wheel is fitted with an external locking ring which engages a spring-loaded pawl so that the drum can be locked in the mixing and discharge positions, respectively.

The machine is available either with four wheels, as shown in the illustration, or with two wheels. In the latter case, the upright to which the forecarriage is secured is extended downwards so that its base acts as a forward support, and the machine is moved by a drawbar the end of which passes through the front of the upright and enters a socket fitted beneath the frame; when not in use, the drawbar can be pushed into the frame of the machine. Both the four-wheeled and two-wheeled machines can be fitted either with the pressed-steel wheels shown in the illustration or with pneumatic-tyred wheels.

The weight of the four-wheeled machine is approximately 10¼ cwt., that of the two-wheeled machine being 10 cwt.; the weights, however, vary slightly according to the type of engine and road-wheels. The overall height for both types of machine is 5 ft. 9 in. when fitted with pressed-steel wheels, but if pneumatic-tyred wheels are fitted, the height is reduced to 5 ft. 7 in. The length of the four-wheeled machine, measured from the rear of the frame to the centre-line of the front axle, is approximately 6 ft., while the overall length of the two-wheeled machine, excluding the handwheel for the tipping gear, is 6 ft. 2½ in. On both machines the distance from the longitudinal centre-line to the outermost point of the mixing drum is 2 ft., and the wheel-track is 2 ft. 5 in. The maximum internal diameter and depth of the mixing drum are 2 ft. 10⅜ in. and 2 ft. 8½ in., respectively, while the diameter of the opening is 1 ft. 5½ in., and the makers state that a batch can be mixed in one minute.

WORLD SUPPLIES OF TIN.

SOME interesting statistics regarding the world production and consumption of tin are contained in a market report prepared by Mr. C. E. Nighman and Mr. J. B. Umhau, issued recently by the United States Bureau of Mines. The figures relate to the calendar year 1946, and the report states that the total world output for that year, namely, 89,000 long tons, was only 6 per cent. above the total for the previous year, which is described as a "long-time low" figure. Moreover, the aggregate of 89,000 tons is only about 55 per cent. of the pre-war annual average output. A world consumption of the order of 115,000 tons, during 1946, was made possible by drawing on stocks in the United Kingdom and the United States, through the agency of the Combined Tin Committee. Slow progress in the rehabilitation of the tin mines in the Far East, accompanied by unsettled political conditions there and in Bolivia, were considered to be the principal factors retarding the expansion of the production of the metal. The report adds that the output expanded in the Far East during 1947, but preliminary estimates indicate that world requirements may not be met until 1949.

The principal tin-producing countries in 1946 were Bolivia, which exported 37,717 tons; the Belgian Congo, the output of which was 14,095 tons; Nigeria, which was responsible for 10,333 tons; British Malaya, which produced 8,432 tons; and the Netherlands East Indies, which yielded 6,535 tons. The British Malayan production in 1942 and 1943 was, respectively, 15,748 and 26,000 tons, while the corresponding outputs of the Dutch East Indies were 9,812 and 17,457 tons; hence, much leeway remains to be made up in these areas. The production of pig tin in the smelting plants of the United States reached a new high record total of 43,500 tons in 1946. The production from these plants has expanded gradually year by year since 1942, when it stood at 16,168 tons. The second largest producer of pig tin, the United Kingdom, produced 28,500 tons in 1946, compared with 28,000 tons in 1945, 25,000 tons in 1944, 31,026 tons in 1943, and 30,000 tons in 1942. The report contains some detailed particulars of the consumption of tin in the United States. This totalled 80,993 tons in 1946, 83,583 tons in 1945, and 89,969 tons in 1944, and was made up, in each case, of roughly 70 per cent. of virgin metal and 30 per cent. of metal recovered from scrap. The manufacture of tin-plate accounted for 26,127 tons, or about 48 per cent., of the virgin tin consumed in 1946. Of the other metallurgical industries, the production of bronzes and tin-containing brasses took a total of 22,557 tons of tin, solders 17,116 tons, and bearing metals 6,999 tons. In the case of the last three totals, the figure shown is made up of recovered tin, as well as of virgin metal.

SUPPLIES OF FUEL OIL.—In a written answer to Sir R. Glyn in the House of Commons on Thursday, January 29, the Minister of Fuel and Power (the Rt. Hon. H. T. W. Gaitskell) said that adequate supplies of fuel should be available during the next six months for plants which had already been converted to oil firing. He was not aware that lack of tank storage facilities was in some cases preventing sufficient stocks from being accumulated.

REPLACEMENT OF LONDON TRAMS BY PETROL OMNIBUSES.—In reply to a question by Mr. R. Chamberlain in the House of Commons on Monday, January 26, asking whether he would request the British Transport Commission to consider the replacement of trams in South London by electric trolley, instead of petrol, 'buses, the Minister of Transport (the Rt. Hon. A. Barnes) said the decision to employ petrol 'buses had been reached after a careful balancing of financial and traffic considerations. The conversion, however, had had to be postponed. When the time came for it to go forward, the British Transport Commission would no doubt take into account all relevant matters.

DISCUSSION ON PEELING OF MALLEABLE IRON.

A MEETING to discuss the defect of "peeling" in whiteheart malleable iron and the penetration of sulphide in the carburisation of steel will be held at the offices of the Iron and Steel Institute, 4, Grosvenor-gardens, London, S.W.1, at 2 p.m., on Thursday, April 8. Mr. J. G. Pearce, Director of Research of the British Cast Iron Research Association, will be in the Chair. The papers to be discussed include a symposium on peeling, published in the January issue of the monthly *Journal* of the Iron and Steel Institute, and a paper published in the November, 1947, issue of the *Journal*, namely, "Sulphide Penetration and the Carburisation of Steel," by Mr. A. Preece and Mr. K. J. Irvine. The symposium consists of an introduction by Mr. J. C. W. Humfrey and four other contributions, the first of which is entitled, "The Formation of Peel on Whiteheart Malleable Cast Iron," by Mr. A. Preece and Mr. K. J. Irvine. The second contribution is by Mr. J. S. Bowden and deals with "Peel on Whiteheart Malleable Cast Iron"; the third, entitled "Peeling of Whiteheart Malleable Iron," is by Mr. G. R. Webster and Mr. A. E. Probst; and the fourth contribution, on "Experimental Work Carried Out at the British Cast Iron Research Association," is by Mr. J. Bernstein. We are informed that members of the Institute of British Foundrymen and of the staffs of member firms of the British Cast Iron Research Association are invited to attend the meeting and join in the discussion. Further particulars, regarding the provision of advance copies of the papers to non-members of the Iron and Steel Institute and other matters connected with the meeting, are obtainable from the secretary of the Institute at the address given above.

LAUNCHES AND TRIAL TRIPS.

M.S. "DARA."—Single-screw passenger and cargo vessel, designed to carry 20 first class passengers, 30 second class, 24 intermediate class, in addition to a large number of unberthed passengers in the 'tween decks. Built by Messrs. Barclay, Curle and Company, Limited, Clydeholm Shipyard, Glasgow, W.4, for the Eastern services of the British India Steam Navigation Company, Limited, Leadenhall-street, London, E.C.3. Main dimensions: 399 ft. by 54 ft. 9 in. by 27 ft.; gross tonnage, 5,000. Barclay Curle-Doxford five-cylinder opposed-piston Diesel-type engine, giving a speed of 14 knots. Launch, December 17.

S.S. "HELKA."—Single-screw vessel for the carriage of fruit and general cargo, with accommodation for ten passengers, built by The Burntisland Shipbuilding Company, Limited, Burntisland, Fife, for Messrs. Euxine Shipping Company, Limited, Bury-street, London, E.C.3. Main dimensions: 312 ft. by 44 ft. 6 in. by 29 ft. 1 in. to shelter deck; deadweight capacity, 3,640 tons. Triple-expansion engine, with two boilers, designed and built by Messrs. Hall, Russell and Company, Limited, Yorkplace, Aberdeen, to give a service speed of 12 knots in fine weather. Trial trip, December 29.

M.S. "MUNSTER."—Twin-screw cross-channel vessel having accommodation for 225 first class and 107 third class passengers, and providing for the carriage of general cargo, motor cars, about 470 cattle and eight horses. Built and engined by Messrs. Harland and Wolff, Limited, Queen's Island, Belfast, for the Dublin/Liverpool service of the British and Irish Steam Packet Company, Limited, North Wall, Dublin, C.10, the vessel will operate temporarily on the Cork/Fishguard service until the completion of her sister ship, the Leinster. Main dimensions: 367 ft. by 50 ft. by 19 ft.; gross tonnage, about 4,000. Two Harland-B. and W. ten-cylinder two-stroke trunk-type airless-injection Diesel engines, giving a service speed of about 17 knots. The propellers are of manganese bronze. Trial trip, January 15 and 16.

M.S. "ACHILLES."—Single-screw cargo vessel for the carriage of refrigerated cargo and up to 2,450 tons of vegetable oils, and with accommodation for twelve passengers. Built by The Caledon Shipbuilding and Engineering Company, Limited, Caledon Shipyard, Dundee, to the order of Messrs. Alfred Holt and Company, India Buildings, Liverpool, 2, for the Ocean Steamship Company, Limited. Main dimensions: 450 ft. by 62 ft. by 35 ft.; deadweight capacity, 9,300 tons. Eight-cylinder double-acting two-stroke B. and W.-type Diesel engine developing 7,500 brake horse power, constructed by Messrs. John G. Kincaid and Company, Limited, East Hamilton-street, Greenock, with a sea speed of 16 knots. Trial trip, January 20.

WIRELESS AND TELEVISION LICENCES.—It is announced that the number of wireless licences in force in Great Britain and Northern Ireland on December 31, 1947, was 11,056,900, including 32,700 television licences. This represented an increase of 278,950 during the twelve months.

BOOKS RECEIVED.

Ministry of Fuel and Power. Twenty-Fifth Annual Report of the Safety in Mines Research Board. 1946. H.M. Stationery Office, Kingsway, London, W.C.2. [Price 1*s.* 3*d.* net.]

Ministry of Transport. Railways Division. Railway Accidents. Report on the Derailment Which Occurred on the 21st July, 1947, near Polesworth on the London Midland and Scottish Railway. [Price 2*s.* net.] *Report on the Collision Which Occurred on the 24th October, 1947, near South Croydon Junction on the Southern Railway.* [Price 2*s.* net.] H.M. Stationery Office, Kingsway, London, W.C.2.

The British Electrical and Allied Industries Research Association. Technical Reports. No. W/T14. *Electrical Soil Sterilization by Immersion Heaters.* By C. A. CAMERON BROWN and P. WAKEFORD. Offices of the Association, 15, Savoy-street, Strand, London, W.C.2. [Price 6*s.* 6*d.* net.]

Encyclopedia of Chemical Technology. Edited by RAYMOND E. KIRK and DONALD F. OTHMER. Volume I. *A to Anthrimides.* The Interscience Encyclopedia, Incorporated, 215, Fourth-avenue, New York 3, U.S.A. [To be completed in 10 volumes, price 20 dols. per volume.]

The Plating of Zinc Alloy Die Castings. Zinc Alloy Die Casters Association, Lincoln House, Turl-street, Oxford; and Machinery Publishing Company, Limited, National House, West-street, Brighton 1. [Price 7*s.* 6*d.*]

Ministry of Fuel and Power, and British Intelligence Objectives Sub-Committee. Technical Report on the Ruhr Coalfield. By a Mission from the Mechanisation Advisory Committee of the Ministry of Fuel and Power. Volume III. Appendix No. 8. *A Study of Efforts to Increase Face Outputs.* By DR. ERNEST GLEBE. H.M. Stationery Office, Kingsway, London, W.C.2. [Price 2*s.* net.]

Heat Engines. By S. H. MOORFIELD and H. H. WINSTANLEY. Third edition. Edward Arnold and Company, 41 and 43, Maddox-street, London, W.1. [Price 8*s.* 6*d.*]

"Mechanical World" Monographs. No. 13. *Industrial Electrical Instruments.* By G. W. STUBBINGS. Emmott and Company, Limited, 31, King-street West, Manchester, 3. [Price 1*s.* 6*d.* net.]

Transactions of the Institution of Civil Engineers of Ireland. Volume 73. Session 1946-47. Offices of the Institution, 35, Dawson-street, Dublin.

Society of Incorporated Accountants. Company Accounts Under the Companies Act, 1947. Prepared for the Incorporated Accountants' Research Committee by F. SEWELL BRAY and H. BASIL SHEASBY. Offices of the Society, Incorporated Accountants' Hall, Victoria-embankment, London, W.C.2. [Price 2*s.* post free.]

Why Not English? A New Alphabet for the English Language. By PETER D. RIDGE-BEEDLE. The Stratford Press, 116, Hope-street, Glasgow, C.2. [Price 10*s.* 6*d.*]

Atomic Energy: Its International Implications. A Discussion by a Chatham House Group. By SIR HENRY DALE, O.M., F.R.S., and others. The Royal Institute of International Affairs, Chatham House, St. James's-square, London, S.W.1. [Price 4*s.* net.]

Concrete Waterproofing. By L. E. HUNTER. Sir Isaac Pitman and Sons, Limited, Parker-street, Kingsway, London, W.C.2. [Price 12*s.* 6*d.* net.]

Magnesium Fabrication. By L. B. HARKINS. Pitman Publishing Corporation, 2, West 45th-street, New York 19, U.S.A. Sir Isaac Pitman and Sons, Limited, Parker-street, Kingsway, London, W.C.2. [Price 20*s.* net.]

Chemical Engineering Fundamentals. By CHALMER G. KIRKBRIDE. McGraw-Hill Book Company, Incorporated, 330, West 42nd-street, New York 18, U.S.A. [Price 5 dols.] McGraw-Hill Publishing Company, Limited, Aldwych House, Aldwych, London, W.C.2. [Price 30*s.*]

Central Board of Irrigation, Punjab. Publication No. 36. *The Role of Glaciers and Snow on Hydrology of Punjab Rivers.* By KANWAR SAIN. The Secretary, Central Board of Irrigation, Simla, Punjab.

Canal de Experiencias Hidrodinámicas de el Pardo. Indice de Bibliografía Sobre Resistencia a la Marcha y Propulsión de Buques y Materias Hidro y Aerodinámicas Afines. 1945 *and* 1946. The Director, Canal de Experiencias Hidrodinámicas de el Pardo, Madrid.

Boiler House and Power Station Chemistry. By DR. WILFRID FRANCIS. Second edition. Edward Arnold and Company, 41 and 43, Maddox-street, London, W.1. [Price 21*s.* net.]

Form Tools: A Guide to Their Design, Manufacture and Use. By WILLIAM F. WALKER. Edited by ERIC N. SIMONS. Hutchinson's Scientific and Technical Publications, 47, Princes-gate, South Kensington, London, S.W.7. [Price 25*s.* net.]

Bentley's Machine Shop Companion. Eleventh edition. The Bentley Publishing Company, 31, King-street West, Manchester, 3. [Price 2*s.* 6*d.* net.]

PERSONAL.

SIR THOMAS BROCKLEBANK, BT., has resigned his directorship of the Cunard Steam Ship Company, Limited, and Cunard White Star Limited, for health reasons.

MAJOR-GENERAL G. N. RUSSELL, C.B., C.B.E., has been appointed chairman of the Road Transport Executive, British Transport Commission. MR. C. BARRINGTON, M.I.Mech.E., M.Inst.T., MR. G. CARDWELL, M.Inst.T. MR. H. E. CLAY, and MR. A. HENDERSON, M.Inst.T., have been appointed full-time members of the Executive, and MR. W. BECKETT, MR. H. DUTFIELD, M.Inst.T., and MR. P. J. R TAPP, C.B.E., M.C., M.Inst.T., part-time members.

MR. E. A. F. JOHNSTON, B.Sc., M.I.C.E., has been released by the Ministry of Works and took up the appointment of Director of Works to the Government of Northern Ireland on February 1.

MR. T. R. WARREN, M.A. (Cantab.), B.Sc. (Lond.), M.I.E.E., has been appointed Chief Engineer and MR. T. J. MULLAN, M.A. (Edin.), LL.B., secretary of the South-East Scotland Electricity Board.

MR. R. FERGUSON, M.I.Mech.E., has been appointed consultant director of Messrs. F. Perkins, Limited, Peterborough. MR. A. GRIFFITHS, formerly with the Ford Motor Company, Limited, Dagenham, has been appointed to the board as director and general manager.

MR. W. H. VICKERS, M.B.E., A.M.I.C.E., M.I.Struct.E., a director of Moreland, Hayne and Company, Limited, 80, Goswell-road, London, E.C.1, has been appointed managing director of the company.

MR. A. C. WILDSMITH has resigned the honorary secretaryship of the North Western Branch of the Institution of Civil Engineers as he is leaving Manchester shortly to take up the position of Deputy Waterworks Engineer, Tynemouth.

MR. D. C. BURTON, B.Sc., A.M.I.Mech.E., has been appointed experimental engineer responsible for Diesel-equipment development and engine testing with C.A.V. Limited, Acton, London, W.3. MR. A. T. PRIDDLE, director and chief development engineer of the firm, has been appointed joint general manager.

MR. JOHN CARTLAND, M.C., M.Sc. (B'ham), F.I.M., has been elected a member of Council of the Printing and Allied Trades Research Association.

MR. H. H. PARTINGTON, formerly general manager of the Grampian Electricity Supply Company, has been made an additional member of the Fisheries Committee under the Hydro-Electric Development Act.

Consequent on the retirement of MR. H. ROBERTS, owing to ill-health, MR. F. H. MAIDEN, A.M.I.E.E., A.M.I.Mech.E., has been appointed manager of the turbine-contracts department, Brush Electrical Engineering Company, Limited. Mr. Maiden is also responsible for all electrical contracts.

MR. J. W. WATKINS, divisional operating manager, Crewe, has been appointed acting assistant chief operating manager, London Midland Region, British Railways.

MR. F. KOENIGSBERGER, Dipl. Ing., M.I.Mech.E., has joined the staff of the Department of Mechanical Engineering, Manchester College of Technology, where he will be mainly engaged in teaching and research in welding.

MR. N. E. KEARLEY, A.M.I.E.E., deputy director, Council of Industrial Design, Tilbury House, Petty France, London, S.W.1, has resumed duty in the Electrical Plant Division, Ministry of Supply, having completed his period of loan from the Civil Service to the Council.

MR. M. N. STATON, 79, Dene-avenue, Hounslow, Middlesex, has been appointed technical representative to Messrs. S. Briggs and Company, Limited, Burton Engineering Works, Burton-on-Trent.

MR. EDWARD JONES has been appointed sales manager to Towler Brothers (Patents), Limited, Rodley, near Leeds.

MR. F. J MARTIN, general manager of the Coventry Victor Motor Company, Limited, Coventry, has resigned to take up an appointment in the United States.

MESSRS. MUSGRAVE AND COMPANY, LIMITED, St. Ann's Works, Belfast, have removed their Bristol area branch from Bloomfield-road, Bath, to more commodious premises at Service House, 14-15, Merchant-street, Bristol, 1.

The name of the ALUMINIUM PLANT AND VESSEL COMPANY, LIMITED, has been changed to the A.P.V. COMPANY LIMITED, Wandsworth Park, London, S.W.18.

THE HOFFMANN MANUFACTURING COMPANY, LIMITED, Chelmsford, Essex, have opened a branch office at 23, Dublin-road, Belfast. (Telephone No. 20741).

A new company named RICHARD CRITTALL MARINE LIMITED, has been formed to carry out work formerly performed by RICHARD CRITTALL AND COMPANY, LIMITED, Liverpool Marine Department. The work will be under the supervision of MR. G. ANGUS, 8, Mosley-street, Newcastle-upon-Tyne, and the direction of MR. J. P. HAMILL, Liverpool.

NOTES FROM THE NORTH.

GLASGOW, Wednesday.

Scottish Steel.—The starting up of the new blast-furnace at Messrs. Colvilles works has proved timely, as one of the furnaces belonging to Bairds and Scottish Steel, Limited, has now had to be taken out of commission for major repairs. The unit, which provided about 100 tons of pig-iron a day, had been operating longer than the normal period. Some months may elapse before it will be ready for relighting. No replacement furnace is available at the premises, but one of the idle Scottish furnaces at other works may be blown in. The effect of the modern furnace at Tollcross Works is already apparent in the amount of pig-iron available for steel-works. Greater importance than ever is attached to the output of pig-iron, on which steelmakers are having to place increasing reliance in view of the limited success of the scrap-collection scheme. It would appear that some revision of delivered prices will be necessary to stimulate collection. In the meantime the commodity is in very short supply. So far, ingot outputs have been maintained at a high level. Re-rollers continue fully occupied with heavy order books, and are receiving substantial quantities of billets, slabs, and sheet bars. Shipbuilders' supplies have not been reduced so far. Encouraging support for the belief that cuts to the industry will be less drastic than was at one time feared, continues to be forthcoming. Recent statements by the Economic Secretary to the Treasury now make it appear that in his original announcement on the subject, Sir Stafford Cripps really meant that there was to be a cut of 20 per cent. in the amount of steel the shipbuilding industry estimated it would require this year, and not 20 per cent. in the allocation. The chairman of the Scottish Board for Industry has announced that his information was that the allocations would be actually higher than last year, the important point being that deliveries would not be guaranteed.

Scottish Coal.—Divisional outputs continue to exceed those of a year ago, but recent production has been at a rate equivalent to only 24,000,000 tons per annum, compared with the target figure of 25,000,000 tons. Consumers' supplies have been on a satisfactory scale, although complaints regarding quality are being heard from industrial users. Gasworks, electric power stations, railways, steelworks, and coke-ovens are holding reasonable stocks, which, as a result of milder weather, have not been encroached upon to the same extent as last year. Many inquiries for supplies continue to circulate in the export trade, but there has been a lull in actual business for a period. Shipments have been moving regularly from Fife to Southern Ireland, while about 2,000 tons of washed fuel a week are being shipped from Ayr to Dublin, principally for electric power stations.

NOTES FROM SOUTH YORKSHIRE.

SHEFFIELD, Wednesday.

Iron and Steel.—The demand for local brands of pig-iron and for hematite iron is unabated and, at times, exceeds the supply. Some success is attending the efforts to secure larger supplies of iron and steel scrap for re-melting, and scrap merchants are trying to expedite sorting. Finished iron is in good demand and the district is being called upon for better supplies of bar iron. The production of open-hearth steel is being well maintained, and in some cases increased. Electric melting furnaces are actively employed, and there is steady production at the coke-fired crucible furnaces, but more high-carbon and high-speed tool steel is required. There is considerable activity in wire-rod rolling, wiredrawing and the manufacture of wire ropes. Progress is being made with the production of coal-mining machinery and equipment, and makers of American-type machinery for deep-mines and opencast sites are dealing satisfactorily with the demand.

South Yorkshire Coal Trade.—A few pits have recently exceeded their targets and many are producing more coal than a year ago. The demand is being fairly well met as a result of more expeditious movement of coal traffic by rail and road, and the more rapid completion of wagon repairs. Washed and graded steams are heavily sold forward, locomotive hards are in adequate supply. A little more activity at coke works has followed the more generous allocations of coking coal, thus providing more hard coke and a better supply of coke-oven gas.

TELEPHONE SYSTEM SHORTAGES.—Moving the second reading of the Post Office and Telegraph (Money) Bill in the House of Commons on Friday, January 30, the Postmaster-General (Mr. W. Paling) said that the total number of new telephones provided during 1946 and 1947 was 1,322,000, compared with 791,000 in 1936 and 1937, an increase of 67 per cent. There were, however, still 450,000 outstanding applications, more than 300,000 of which could not be dealt with until new ducts or cables had been provided. At 1,500 of the 5,800 exchanges, the equipment was fully in use and new subscribers could not be accepted until they had been extended.

NOTES FROM THE SOUTH-WEST.

CARDIFF, Wednesday.

Welsh Coal Trade.—Testifying to the importance of Welsh coal in trade negotiations with other countries, Mr. Harold Wilson, President of the Board of Trade, speaking in the Welsh debate in Parliament, said that the South Wales colliery industry could look forward to an expanding programme of exports in the future. Following closely upon the debate came news that the first supplies of coal from this district for the Argentine, for a considerable time, had been arranged. It was reported that a shipment of 7,500 tons would be made early in February and that a similar amount would be sent later in the month. It will be recalled that it was stated recently that agreement had been reached at the Anglo-Argentine trade talks for an immediate resumption of coal deliveries by Great Britain. Two cargoes for Uruguay have been loaded at South Wales ports during the week. These were also the first consignments of coal to be sent since early in the war. It was reported that France had made arrangements to take about 1,000 tons of Welsh anthracites. Belgium too was reported to be interested in obtaining some anthracites, while the release of about 1,000 tons was reported for users in Sweden. The supply position on the market was extremely difficult and prevented shippers from accepting a number of orders that were available from overseas consumers. The high-priority home consumers were making heavy calls and were taking the bulk of current outputs. Bunker descriptions were in steady demand while cokes continued scarce and patent fuel was well sold forward.

Swansea Steel-Sheet Industry.—The market report issued by the Incorporated Swansea Exchange states that, last week, there was some activity in tin-plate, and the quantities sold to both home and overseas consumers, for delivery during the current quarter and subsequently, were on a satisfactory scale. In the export market, the demand was strong, and, with more material released, the number of orders was appreciable. Steel sheets continue to meet with an exceptionally strong demand; iron and steel scrap of all descriptions is also in keen request and great efforts are being made to augment the supply.

NOTES FROM CLEVELAND AND THE NORTHERN COUNTIES.

MIDDLESBROUGH, Wednesday.

General Situation.—The total tonnage output of iron and steel is being maintained at a very high level, but the demand for larger deliveries of Tees-side products continues and is much greater than the producers can provide. The scarcity of pig iron is somewhat less acute than of late and rather better supplies of scrap are coming forward, but the demand for all these commodities is still greatly in excess of the quantities available. The advance in values announced last week is strictly related to the increased cost of coal and raises the general level of iron and steel prices to much above pre-war figures. As the advances are not retrospective, producers are getting no compensation for the extra cost of fuel since the beginning of the year.

Foundry and Basic Iron.—Ordinary foundry pig iron is still required in much larger parcels than are obtainable and the shortage, coupled with the inadequate distributable tonnage of cast-iron scrap, is restricting the production of light castings and other foundry outputs. North-East Coast founders have still to depend very largely on the supply of pig iron from the Midlands. The output of basic iron is barely sufficient for the essential needs of makers' own consuming plants.

Hematite, Low-Phosphorus and Refined Iron.—Users of East Coast hematite continue to receive sufficient tonnage for their current needs but their efforts to secure parcels of iron for stocking purposes are still unsuccessful. The outputs of low- and medium-phosphorus grades of iron are quickly taken up and the make of refined iron is readily absorbed.

Manufactured Iron and Steel.—Semi-finished and finished iron firms are busily occupied and have good bookings, while steel manufacturers have very heavy contracts to carry out. Makers of steel semies are supplying re-rollers with better parcels of billets, blooms and slabs, but this is counteracted by further shrinkage in imports; small billets, especially, are in strong demand. Substantial parcels of ingots are reaching the heavy rolling mills, from which the outputs are on a remarkably good scale. The branches of industry turning out plates and heavy joists are as busily employed as conditions permit, plants producing railway requisites are fully occupied and orders for colliery equipment have reached formidable proportions.

INSTITUTE OF TRANSPORT.—The East Midlands Section of the Institute of Transport has formed a Leicester Group. The honorary secretary is Mr. P. A. Goodridge, City Transport Offices, Humberstone Gate, Leicester.

NOTICES OF MEETINGS.

It is requested that particulars for insertion in this column shall reach the Editor not later than Tuesday morning in the week preceding the date of the meeting.

INSTITUTION OF ELECTRICAL ENGINEERS.—*North-Eastern Centre:* Monday, February 9, 6.15 p.m., Neville Hall, Newcastle-upon-Tyne. "Lightning Strength of Power Transformers," by Mr. E. T. Norris. *Radio Section:* Tuesday, February 10, 5.30 p.m., Victoria-embankment, W.C.2. Discussion on "Maintenance of Television Receivers," opened by Mr. G. H. Watson. *Western Centre:* Tuesday, February 10, 6 p.m., Reardon-Smith Lecture Theatre, Cardiff. "Electricity and Everyman," by Dr. P. Dunsheath. *North-Midland Centre:* Tuesday, February 10, 6.30 p.m., Electricity Dept., Whitehall-road, Leeds. "Standardisation of Switchgear," by Messrs. D. E. Lambert and J. Christie. *East Midland Centre:* Tuesday, February 10, 6.30 p.m., Gas Dept., Nottingham. "Speech Communication," by Dr. W. G. Radley. *Transmission Section:* Wednesday, February 11, 5.30 p.m., Victoria-embankment, W.C.2. "Centralised Ripple Control on High-Voltage Networks," by Messrs. T. W. Ross and R. M. A. Smith. *Mersey Centre:* Wednesday February 11, 6 p.m., 9, The Temple, Dale-street, Liverpool. "Electricity on Ships," by Mr. R. G. A. Dimmick. *Southern Centre:* Wednesday, February 11, 6.30 p.m., The Pavilion, Bournemouth. "Sources of Auxiliary Power," by Mr. W. E. Warrilow.

INSTITUTION OF PRODUCTION ENGINEERS.—*London Section:* Thursday, February 12, 7 p.m., Royal Empire Society, Northumberland-avenue, W.C.2. "Inspection," by Messrs. P. S. Crooke and A. G. Powell.

JUNIOR INSTITUTION OF ENGINEERS.—*Sheffield Section:* Monday, February 9, 7.30 p.m., 198, West-street, Sheffield. "Engineering Industry: Past, Present and Future," by Mr. McGuire. *Western Group:* Tuesday, February 10, 7.30 p.m., Technical College, Bath. "Engineers in Tanks," by Maj.-Gen. G. L. Watkinson. *Institution:* Friday, February 13, 6.30 p.m., 39, Victoria-street, S.W.1. "A Passenger Chassis for Service in India," by Mr. W. J. Kease.

INSTITUTE OF BRITISH FOUNDRYMEN.—*Sheffield Branch:* Monday, February 9, 7.30 p.m., Royal Victoria Hotel, Sheffield. "Fuel Economy in the Foundry," by Prof. R. J. Sarjant.

INSTITUTE OF MARINE ENGINEERS.—Tuesday, February 10, 5.30 p.m., 85, The Minories, E.C.3. "Longitudinal Vibration of Marine Propeller Shafting," by Mr. C. P. Rigby.

INSTITUTION OF CIVIL ENGINEERS.—Tuesday, February 10, 5.30 p.m., Great George-street, S.W.1. "Barrel Vault Shell Concrete Roofing," by Mr. C. V. Blumfield. *Birmingham Association:* Thursday, February 12, 6 p.m., James Watt Institute, Birmingham. "Unique Method of Constructing Hyperbolic Cooling Towers," by Mr. B. G. Carroll.

INSTITUTION OF ENGINEERS AND SHIPBUILDERS IN SCOTLAND.—Tuesday, February 10, 6.30 p.m., 39, Elmbank-crescent, Glasgow. "Design of Ships' Refrigerating Equipment," by Dr. A. J. Smith and Mr. J. D. Farmer.

INSTITUTION OF LOCOMOTIVE ENGINEERS.—Wednesday, February 11, 5.30 p.m., Institution of Mechanical Engineers, Storey's-gate, S.W.1. "Carriage Bogie Design," by Mr. Jury Koffman.

NEWCOMEN SOCIETY.—Wednesday, February 11, 5.30 p.m., Chartered Institute of Patent Agents, Staple Inn Buildings, W.C.1. "Trevithick and the Merthyr Tramroad," by Mr. S. Mercer.

INSTITUTION OF MECHANICAL ENGINEERS.—*South Wales Branch:* Wednesday, February 11, 6 p.m., Town Hall, Newport, Mon. "Norwich Heat Pump," by Mr. J. A. Sumner. Also at the *Western Branch:* Thursday, February 12, 7 p.m., Merchant Venturers' College, Bristol. *Yorkshire Branch:* Thursday, February 12, 7 p.m., University, Leeds. "Industrial Applications of the Gas Turbine," by Dr. A. T. Bowden. *Institution:* Friday, February 13, 5.30 p.m., Storey's-gate, S.W.1. "Large-Scale Torsional-Fatigue Testing of Marine Shafting," by Dr. S. F. Dorey. AUTOMOBILE DIVISION. *Coventry Centre:* Tuesday, February 10, 7 p.m., Geisha Café, Coventry. "Test Methods and Instruments," by Mr. E. B. Stead. *North-Eastern Centre:* Wednesday, February 11, 7.30 p.m., University, Leeds. "Public Service Vehicles," by Mr. D. M. Sinclair.

ROYAL SOCIETY.—Thursday, February 12, 4.30 p.m., Burlington House, Piccadilly, W.1. "Lattice Spacings of Solid Solutions of Different Elements in Aluminium," by Messrs. H. J. Axon and W. Hume-Rothery, F.R.S. "The Thermal Etching of Silver," by Messrs. B. Chalmers, R. King and R. Shuttleworth.

INSTITUTION OF STRUCTURAL ENGINEERS.—Thursday, February 12, 6 p.m., 11, Upper Belgrave-street, S.W.1. "Structural Engineering Research at the Building Research Station," by Dr. F. G. Thomas.

ROYAL INSTITUTION.—Friday, February 13, 9 p.m., 21, Albemarle-street, W.1. "Physical Problems in Oil Production," by Prof. A. O. Rankine, F.R.S.

AIRCRAFT POWER PLANT ENGINEERING.

(*For Description, see Page* 127.)

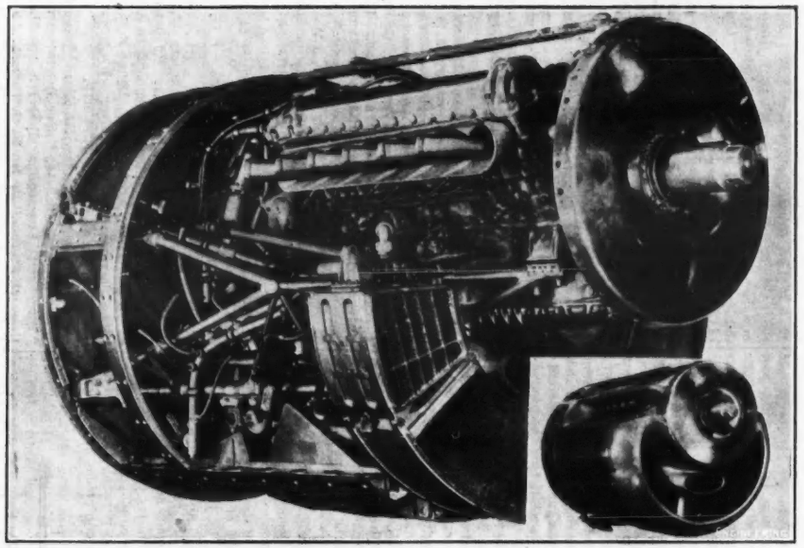


FIG. 3. MERLIN "NORTH STAR" POWER PLANT.

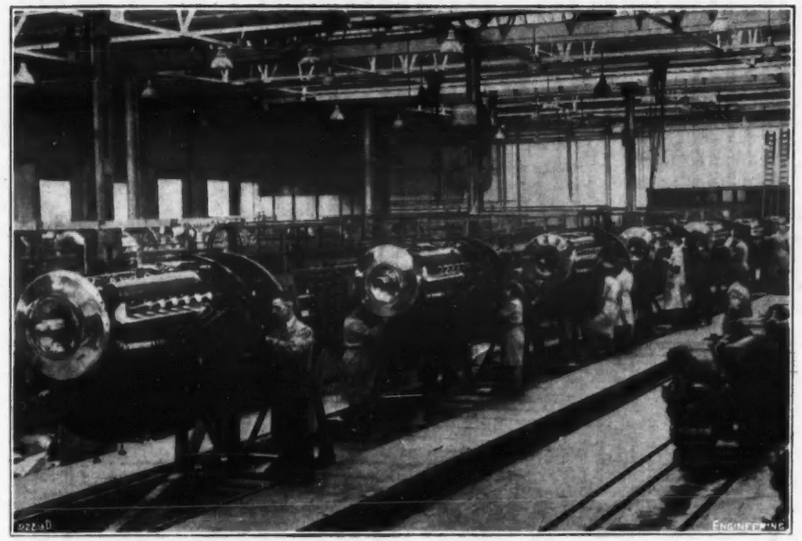


FIG. 4. PRODUCTION LINES AT ROLLS-ROYCE ILKESTON FACTORY.

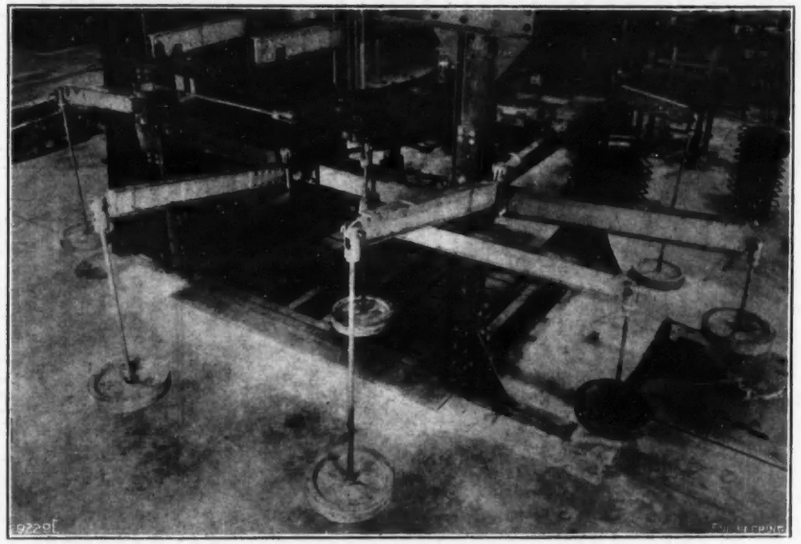


FIG. 5. ENGINE MOUNTING STATIC-TEST RIG.

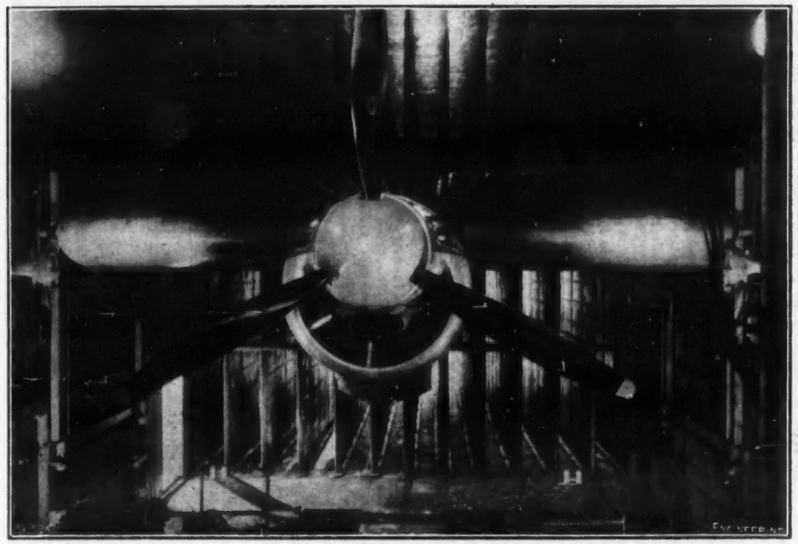


FIG. 6. "WING" TEST HANGAR.

ENGINEERING.

35 & 36, BEDFORD STREET, STRAND, LONDON, W.C.2.

We desire to call the attention of our readers to the fact that the above is the address of our Registered Offices, and that no connection exists between this Journal and any other publication bearing a similar title.

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ADVERTISEMENT RATES.

Terms for displayed advertisements on the green art paper wrapper, on the inside black and white pages and in the buff art paper two-colour supplement, as well as for insets, can be obtained on application to the Manager. The pages are 12 in. deep and 9 in. wide, divisible into four columns 2¼ in. wide. Serial advertisements will be inserted with all practicable regularity, but absolute regularity cannot be guaranteed.

The charge for advertisements classified under the headings of "Appointments Open," "Situations Wanted," "Tenders," etc., is 8*s.* for the first four lines or under, and 2*s.* per line up to one inch. The line averages six words and when an advertisement measures an inch or more, the charge is 24*s.* per inch. If use is made of a box number the extra charge is 1*s.* per insertion, with the exception of advertisements appearing under "Situations Wanted." Series discounts for all classified advertisements can be obtained at the following rates:—5 per cent. for six; 12½ per cent. for thirteen; 25 per cent. for twenty-six; and 33⅓ per cent. for fifty-two insertions.

TIME FOR RECEIPT OF ADVERTISEMENTS.

Classified advertisements intended for insertion in the current week's issue must be received not later than first post Wednesday.

"Copy" instructions and alterations to standing advertisements for display announcements must be received at least 10 days previous to the date of publication, otherwise it may be impossible to submit proofs for approval.

The Proprietors will not hold themselves responsible for advertisers' blocks left in their possession for more than two years.

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ENGINEERING

FRIDAY, FEBRUARY 6, 1948.

VOL. 165. No. 4280.

ORVILLE WRIGHT.

JUST 300 years ago, the Rev. John Wilkins—theologian, mathematician, astronomer, and subsequently a Fellow of the Royal Society, Warden of Wadham College, and Bishop of Chester—turned his inquiring and philosophical mind to the possibility of flight by heavier-than-air machines. Having collected the fairly numerous tales and legends of previous attempts by men to accomplish by art what birds achieved with such apparent ease by nature, he was moved to put on record that, in spite of their failures, "Yet do I seriously, and upon good grounds, affirm it possible to make a flying chariot, in which a man may sit, and give such a motion unto it as shall convey him through the air. And this perhaps might be made large enough to carry divers men at the same time, together with food for their viaticum and commodities for traffic." Then he added, with a clarity of perception truly remarkable in his day and circumstances, "It is not the bigness of anything in this kind that can hinder its motion, if the motive faculty be answerable thereunto." Two centuries elapsed before his dream was partly realised, and then it was only with a model, flown by John Stringfellow (1799-1883) in the Cremorne Gardens, Chelsea, in 1848, and propelled by a miniature steam engine. Stringfellow's friend and collaborator, William Samuel Henson (1805-88) had designed and patented in 1842 the general type of the aeroplane which must be regarded as the prototype of the modern aircraft, but he had abandoned his share of their joint experimental work in 1847 and it does not appear that he was associated in any way with Stringfellow's successful demonstration of his model in August of the following year.

Now, within a few months of the centenary of that historic experiment, the news has come from Dayton, Ohio, of the death there, on January 30, of Orville Wright, who, with his elder brother, Wilbur, first achieved the objective foreseen by Bishop Wilkins and did it, as he had postulated, by their success in making "the motive faculty answerable thereunto." Others had striven towards the same goal in the intervening years, and had shown great ingenuity in devising propelling machinery of exceptionally high power/weight ratio, but they had used steam and thereby, inevitably, had limited the possible duration of their flight, if flight could be accomplished with the aircraft they had devised, to a few minutes at the most. The Wrights turned to the internal-combustion engine and thus doubly earned their status as pioneers of the heavier-than-air machine. In retrospect, indeed, the feat of designing and building a successful motor, because none suitable was to be bought, seems almost more remarkable than that of constructing the machine to carry it, for which there was a considerable amount of guidance available in the work of Lilienthal, Pilcher, and their own fellow-countryman, Professor S. P. Langley. Of this previous experience the brothers took full advantage, though the aircraft that they developed eventually was peculiarly their own.

The two brothers—it is impossible to separate their respective shares in the work, even for the purpose of a memoir, though Wilbur died as long ago as 1912—were both natives of Dayton, which remained the centre of their labours and was their home throughout their lives. Orville, who was the younger by four years, was born on August 19, 1871, so that he was in his 77th year when he died. Like England's Lord Nuffield, they learned their practical mechanics as builders and repairers of bicycles, but they seem to have been attracted by the possibility of aerial flight while still only in their twenties. At first, like Lilienthal and Pilcher, they experimented with gliders and had developed their design of an aircraft practically to its successful form before they installed an engine in it. As Henson and Stringfellow had thought before them, they came to the conclusion that a vertically-disposed rudder was either unnecessary or undesirable; in its place, they devised the method of control by warping the extremities of the supporting aerofoils, and this was one of the main features of their eventual patent specification. Longitudinal stability was attained by means of small wing surfaces carried on outriggers ahead of the main planes; and the aircraft was launched at first by running it on rails down the slope of a hill. There were no wheels, the landing gear consisting of unsprung skids, such resilience as these afforded being due only to their wooden construction. Later, the brothers devised a launching arrangement of a tower and a descending weight, which pulled the aeroplane along the rails; still later, when more powerful engines were obtained, they were able to dispense with the tower.

The first successful flight under power, with Orville Wright at the controls, was made at Kitty Hawk, North Carolina, on December 17, 1903, and, fortunately, was recorded for posterity in a photograph which must be familiar to many thousands of their successors in aeronautical science, since it has been reproduced annually for many years on the cover of the Wilbur Wright Memorial Lectures of the Royal Aeronautical Society. The flight was not of long duration—only 12 seconds—and the distance covered was only 120 ft.; exactly the same as the flight of Stringfellow's model in the Cremorne Gardens in 1848. As a record for duration and distance of flight, it stood for a matter of hours only, for Wilbur Wright, later on the same day, managed to remain in the air for a minute, all but one second, and covered 852 ft. before the machine touched down. Before another flight could be made, a gust of wind overturned the aircraft and damaged it considerably. So far as we are aware, that particular machine was never airborne again; but happily it was preserved, and, in 1924, was presented to the Science Museum, South Kensington, where it is still to be seen, though it is understood to be the intention of the Museum authorities—an intention to which, assuredly, no exception can be taken—to return it to the United States for preservation in the Smithsonian Institution.

For a long time, the Wright brothers were extremely reticent about their success, and it was not until 1908 that they decided that the time had come to turn it to commercial account by endeavouring to interest the United States and other Governments. In France, especially, it was well received; but progress with the United States Government was retarded somewhat by an accident to a machine piloted by Orville Wright, who had progressed by then to the stage of carrying a

passenger, Lieutenant Selfridge, who lost his life. Orville escaped with a broken leg and, though he recovered from the injury, it does not appear that he flew extensively thereafter. In May, 1909, the brothers visited London and introduced themselves and their machine to the British military authorities, who had already taken the encouraging steps of appointing a committee, under Lord Rayleigh, to investigate the possibilities of aviation for the Army and the Navy and had established an aeronautical research department at the National Physical Laboratory.

During their short stay in London, the brothers were extensively fêted, and, at a special meeting of the Royal Aeronautical Society (of which they had been made Honorary Fellows in the previous year), held in the hall of the Institution of Civil Engineers and presided over by Mr. E. P. Frost, were presented with the Gold Medal of the Society. On the following day, they were entertained at a banquet by the Royal Aero Club, at which both of them responded briefly to the speeches made in their honour. Always, however, Orville Wright left most of the speech-making to his brother, though it cannot be said that either of them inclined towards loquacity; a natural trait, no doubt, but probably intensified by their experiences in the United States, where they found themselves involved in long and expensive litigation over patents.

Following the regrettably early death of Wilbur Wright, who died of typhoid fever when only 45 years of age, Orville's retiring disposition seemed to become even more pronounced, though the numerous distinctions which were conferred upon him by universities and professional bodies continued to bring his name periodically before the public, and, as a member of the National Advisory Committee for Aeronautics, he kept in touch with the latest technical developments. In addition to the Gold Medal of the Royal Aeronautical Society, mentioned above, and the medal of the Royal Society of Arts, he was awarded the Gold Medal of the French Academy of Sciences and was a Chevalier of the Legion of Honour. Earlham College, Indiana, and Oberlin College, Ohio, where he received his higher education, conferred upon him the degrees of Master of Science and Doctor of Laws, respectively; from Trinity College, Connecticut, and the University of Cincinnati he received degrees of Doctor of Science; Yale University made him a Master of Arts; and German recognition came from the Royal Technical College at Munich, of which he was a Doctor of Technical Science. In the first World War, he was commissioned in the United States Aviation Corps with the rank of Major. The most recent British distinction conferred upon him was that of honorary membership of the Institution of Mechanical Engineers, in 1942.

Looking back, it is easy now to see that, if the Wright brothers had not devoted themselves to carrying on the work of Lilienthal or if they had decided, as well they might, to abandon their experiments in the face of the misfortunes inseparable from the early stages of glider and powered-aircraft development, as did Langley, it could not have been long before some other of their contemporaries in this field would have succeeded; the advent of the internal-combustion engine, using liquid fuel, made that an eventual certainty. In England and in France, particularly, investigations and experiments were in progress, quite independently of the work that the Wrights were doing, and, it would seem, at first without any certain knowledge of its nature, that must have produced an equivalent result in time, and in a comparatively short time. These facts, however, do not detract in the slightest from the quality of their success; in many respects, indeed, they were much farther in advance of their competitors than was appreciated until they decided to test openly the possibilities of the military and sporting markets for aircraft and to set up as aircraft manufacturers. The success that they achieved, scientifically and commercially, was thoroughly deserved by their long and painstaking efforts, undertaken, apparently, with no other financial support than their own resources, relying in execution upon their own brains and skill, and put to the test at their own personal risk.

EDUCATION FOR INDUSTRY.

THE provision of facilities for theoretical training and education for junior entrants has become almost common practice in the engineering industry. Many large firms operate works schools and smaller ones have concluded arrangements with local technical colleges, under which trade apprentices are released from the shops on specified days, or half-days, in order that they may attend classes. The elaborate system in operation at the Derby Locomotive Works, in which a training workshop is associated with the works school, was described on page 102, *ante*. Although systems of training of this kind are not confined to engineering, it is probably ahead of most industries in the matter, and the almost complete absence of training facilities in some trades was recently the subject of unfavourable comment by the Minister of Labour. The training given in works schools is naturally mainly of a technical character and is intended to give the pupil a better understanding of the workshop activities in which he is engaged and enable him, if he has the mental capacity, to advance to a higher position.

Stated briefly, the aim of technical education is to improve the qualification of the individual as a producer, be he an apprentice, a designer or a managing director; the aim of general education is to develop personality and increase understanding of the complexity of human relations and of the broad issues of life. As a general proposition, it would probably be agreed that of two men of equal technical attainments, the one who has, in addition, the more broadly cultivated mind and the wider understanding of life as a whole will be able to apply his professional qualifications more effectively, even in the strictly technical sphere. A simple illustration of the proposition has been furnished by the British Association for Commercial and Industrial Education who have pointed out that "no man can be expected to focus his energies and loyalties upon what he does not understand." This remark had reference to the wider education of workpeople, the contention being that only by the provision of that wider education "can the energies and enthusiasm of the British people be mobilised and co-ordinated to the extent necessary to enable this country to . . . preserve her standard of life and level of culture." This remark was not to be understood as limited to workpeople; such education was necessary at "every level."

These quotations have been taken from the foreword of the report of a conference of the Association held at Ashridge, Berkhamsted, from October 3 to 6, 1947. The conference carried the title "The Short Road to Industrial Co-operation," which was a little optimistic, as the subject was the raising of general industrial efficiency by improving the level of general education throughout the ranks of employees. Although the value of a broader education in any class is not likely to be denied, the educational advance of the mass of the people will probably not be along a "short road." There is much to be done and, in the course of the discussions which took place at the conference, more than one speaker referred to illiterate or semi-illiterate people coming into industry. The raising of the school-leaving age should do something towards improving matters in this respect, but there were suggestions that many of those falling within these classes had left school at the age of fourteen with a reasonable level of general education, but that subsequent lack of practical application had resulted in the development of near-illiteracy.

To the suggestion that the present period of shortages and industrial difficulty is hardly one at which time and man power should be devoted to the improvement of employee services, the reply is made that it is just because there is an industrial crisis that increased facilities for education and training should be provided within industry." Such education should be treated by management as an integral part of efficient production." The problem was stated as the provision of education "for the unskilled 90 per cent. of employees" to improve their self-respect, interest and loyalty and their adaptability for promotion; and the education and training of the skilled 10 per cent., including the managerial grade, so that their abilities, particularly their skill in leadership, might be fully developed. So much has already been done in some branches of the engineering industry, both by the institution of works schools and the provision of facilities by which graduate apprentices may obtain wide experience of many aspects of business, that it may be assumed that the recommendations of the conference were directed mainly to other trades.

The connection between the titular subject of the conference, "The Short Road to Industrial Co-operation," and this matter of training and education lay in the contention that workpeople and staff alike will learn how to work together for the common good only if they have a broad understanding of each others problems, and the papers which were read at the conference to a considerable extent were concerned with what Mr. F. C. Hooper in his paper, called "the working climate." Mr. Harold Clay, assistant general secretary of the Transport and General Workers Union, in a paper entitled "Trade Union Reactions," admitted that workpeople were suspicious of schemes of education and training sponsored by employers. It was difficult to generalise and a man's opinions varied according to the type of firm for which he was working and with the district from which he came. The trade unions as corporate bodies were certainly not opposed to training and education and the Trades Union General Council had, itself, done considerable work in the educational field. The main text of the conference may be taken to be that the road to improvement in "the working climate" lies in the direction of broader and more extensive education, and Mr. Clay did not suggest that existing suspicions would prevent the development of training schemes; "we are all beginning to realise," he said, "that it is the quality of the individual and his willingness to co-operate which is the most important thing of all."

The statement above that 90 per cent. of workpeople are unskilled is taken from the foreword of the report, but it would seem likely that that proportion is intended to include the semi-skilled. It is difficult to believe that 90 per cent. of the employees in the engineering industry can properly be described as unskilled, and Lt.-Gen. Sir Ronald Weeks, deputy chairman of Vickers Limited, in a paper entitled "The Industrialist's Point of View," stated that in some large engineering and shipbuilding works, 50 per cent. of the workmen were skilled men and 23 per cent. semi-skilled. Sir Ronald briefly described the training provided for trade, pupil and graduate apprentices at the works of Messrs. Vickers. These are in line with what is now widespread practice in large engineering firms and need not be referred to here. He, however, raised a point to which, possibly, wide attention has not been given. That was the training of charge hands and foremen who are "the guts of the organisation from the point of view of day-to-day conduct of the firm." He advocated interchanges of visits of foremen and charge hands to other works and of educational courses away from the job.

The foregoing account has been confined mainly to the question of the education of workpeople, and that is the matter to which the conference devoted the major part of its attention. The subject of the training of managerial grades was not neglected, however, and an informative paper was contributed by Mr. Noel F. Hall, Principal of the Administrative Staff College at Henley. This institution, which is to open next month, has been founded by a number of business organisations in conjunction with the Nuffield Trust. Three-months' courses will be held at which the whole range of administrative problems will be studied. Care will be taken that the methods of instruction adopted do not favour graduates and those who have already received an advanced education, and it is hoped that trade-union officials and promoted workpeople will take advantage of the facilities provided. In the course of one of the discussisns, Dr. Percy Dunsheath referred to the suspicions which may be created in the minds of workpeople when college graduates are admitted to industry and directly trained for managerial positions. Mr. Hall hoped that the Staff College would do something towards lessening such suspicions by providing a medium by which men from shop level might be assisted to qualify for administrative posts.

NOTES.

ALUMINIUM ALLOYS IN SHIP CONSTRUCTION.

NOTICE No. 1879, which has just been issued by Lloyd's Register of Shipping, 71, Fenchurch-street, London, E.C.3, in addition to various modifications in the Rules for steel ships, contains the tentative requirements laid down by the Committee for "Quality and Testing of Aluminium Alloys for Shipbuilding Purposes." A covering note informs us that proposals have been approved recently for the use of such materials in place of mild steel in the main hull structure of ships, as well as for deckhouses, hatch covers, webs, masts, etc., provided that certain precautions are taken. The requirements are set out in three Sections, of which the first deals with the general conditions of testing, facilities for inspection, etc. Section 2 describes how the proof stress, tensile strength, and the ductility are to be determined from standard test-pieces. Section 3 specifies the chemical composition of the permissible alloys, whether heat-treatable or not, the number of tests to be made, and the required physical properties. Where the plates and sections are not heat-treatable, the maximum acceptable percentages of alloying metals are as follows: copper, 0·10; magnesium, 5·50; iron, 0·75; silicon, 0·60; manganese, 1·00; chromium, 0·50; zinc, 0·10. In the case of heat-treatable alloys, the corresponding percentages are: copper, 0·10; magnesium, 1·50; iron, 0·60; silicon, 1·30; manganese, 1·00; chromium, 0·50; zinc, 0·03. It is open to manufacturers, however, to submit other alloys for the Committee's consideration.

THE INSTITUTION OF MECHANICAL ENGINEERS.

At an extra general meeting of the Institution of Mechanical Engineers, held at Storey's Gate, St. James's Park, London, S.W.1, on Friday, January 30, 1948, a paper entitled "Some Recent Developments in the Technique of Radio Valve Manufacture," by Messrs. J. W. Davies, H. W. B. Gardiner, and W. H. Gomm, of the research and engineering staff of the M.O. Valve Company, Limited, and the G.E.C. Research Laboratories, Wembley, was read and discussed. The chair was taken by Dr. S. F. Dorey, C.B.E., vice-president. In their introduction, the authors pointed out that the thermionic valve had established itself as one of the most useful devices of the engineer, but attention had been focused mainly on its electrical performance and the many ingenious and original methods of applying it to the various duties it was required to perform. There were, however, many points in the construction of thermionic valves which would be of general interest to engineers, and the object of the paper was to bring some of these points to the notice of mechanical engineers engaged in work other than valve manufacture, since some of the processes employed might find useful application in different spheres. To illustrate their remarks, the authors dealt with three valves of recent design, and briefly described their fundamental features and construction. These were the C.A.T. 17, a high-power triode transmitting valve for broadcast and telegraph service, which is typical of many others used in similar applications; the C.V. 240, which is a modern short-wave triode with a cylindrical electrode system; and the C.V. 257 valve, this being a triode having a flat electrode system suitable for use on very high frequencies. The design and methods of construction used for the cathodes, grids and anodes of these valves were illustrated and described in detail. Particularly interesting sections of the paper were devoted to the manufacture of grids of the coiled, squirrel-cage and planar types, and to the methods employed for making glass-to-metal seals. The machines and operations employed for the production of these components were explained in detail and were effectively illustrated by cinematograph films. A discussion, in which eight speakers took part, followed the presentation of the paper, and each of the authors replied briefly to a few of the points raised; it was stated, however, that the main reply would be made in writing. A vote of thanks to the authors proposed by the chairman and carried by acclamation, concluded the proceedings.

RESEARCH ASSOCIATIONS AND LIABILITY FOR RATES.

A case, which will be of interest to others than the parties immediately concerned, was decided in the King's Bench Division last week. The facts are that the British Launderers Research Association applied to the Central Middlesex Assessment Committee for the amendment of the valuation list in respect of certain premises which they owned and occupied. This application was rejected, but was upheld on appeal by the Middlesex Quarter Sessions. The ground for the application was that the premises were exempt from rates under the Scientific Societies Act, 1843, the Association being "a society instituted for purposes of science . . . exclusively." The premises in question consist of scientific laboratories, a drawing office, machine shop, library, experimental laundry and other buildings; and the Association derives its income from a grant and from students' and technical advice fees. Its activities include the investigation of scientific problems, not necessarily confined to the laundry industry, the visiting of laundries by technical advisers, and the conduct of courses for students desirous of becoming managers of commercial laundries. The rating authority, however, argued that the Association had a dual purpose: the promotion of science by research and other means; and the advancement of the interests of its members engaged in the trade or industry of laundering. In giving judgment on a further appeal by the rating authority, Mr. Justice Humphreys held that, to come within the exemption, the Association must have been established exclusively for the promotion of science and, if instituted thus exclusively, would not lose its rights merely because in attaining that object it did things which benefited its members in pursuit of their trade. His Lordship, however, thought that the Association had two purposes, one being the promotion of science and the other that of giving advice and assistance to members of the laundry trade on carrying on their business. The second purpose was not merely ancillary or incidental to the first, but was separate and independent. His judgment was that the appeal should be allowed, and the Court agreed. We understand that leave to appeal further has been granted.

NAVAL DEVELOPMENT OF THE GAS TURBINE.

The experimental gas-turbine propelling machinery which was installed in H.M. motor gunboat 2009 and was described in ENGINEERING, vol. 164, page 271 (1947), has now completed 55 hours operational running and has been returned to the manufacturers, Messrs. Metropolitan-Vickers Electrical Company, Limited, Manchester, for examination. Originally, it was intended to operate the gas turbine for approximately 30 hours and then return it to the manufacturers' works for examination and overhaul prior to its installation for a second series of trials. The behaviour of the turbine at sea, however, was so satisfactory that the trials were extended to the 55 hours already mentioned. On inspection at the maker's works, the unit proved to be in good order, the condition of the compressor blading being exceptionally satisfactory. There were, however, slight indications of salt having been deposited on the blading, but in this connection it is interesting to record that the manufacturers have had previous experiences of salt formation on compressor blading and have found that by washing the compressor with fresh water, the salt is dissolved and the performance unimpaired. The gas generator and power turbines were in good condition and the amount of carbon formed in the combustion chamber proved to be small, while only minor distortion of the primary chamber had occurred. The reduction gearing also proved to be in a satisfactory condition and there were no signs of undue wear in any of the components. It is understood that no modification will be incorporated in the unit, and that it will be sent on the second series of trials in its present form. In the interim period, M.G.B. 2009 is to be fitted with a new, slightly modified, unit which will be run continuously for long periods, so that the total useful life at sea may be ascertained. The Admiralty is also arranging for a larger gas-turbine unit to be installed in a vessel of the escort type. On this project, the machinery has been designed for marine purposes from the initial stage, and it is predicted that its durability and efficiency will be greater than those of the units fitted to M.G.B. 2009. Another project is the fitting of gas-turbine machinery to H.M.S. Grey Goose, a gunboat of 250 tons, at present fitted with steam-turbines.

THE BRITISH SHIPBUILDING RESEARCH ASSOCIATION.

The second annual report of the British Shipbuilding Research Association, recently issued by the Council of the Association from their offices at 5, Chesterfield-gardens, Curzon-street, London W.1 (which premises they have now purchased, as the report discloses), covers a period of 15 months, from January 1, 1946, to March 31, 1947. Future reports, it is stated, will cover a year, ending on March 31 in each case. During the 15 months, the only alteration made in the list of committees consists of the addition of an Inventions Committee, under the chairmanship of Dr. J. M. McNeill, but some panels have been appointed for special purposes. There are now 75 ordinary members of the Association, these being shipbuilding, ship-repairing or marine-engineering firms, each of whom appoints one representative; but there are 152 members of committees, of whom, in addition to 63 representatives of member firms, there are 20 from the shipping industry, 12 from the classification societies, 24 from Government departments and research establishments, and 12 from universities and technical colleges. The remaining 21 are persons with various special qualifications. The staff amounted to 56 at the close of the period under review. A full list of the subjects for research is included in the report, though in some cases no active research was being undertaken when it was compiled. The main divisions of the research programme are concerned with hydrodynamics, ships' structures, ships' machinery, structures and machinery in combination (mainly questions of vibration), and the performance of ships. In these several fields, the research work of the Association falls into two main categories, one being the survey and collection of existing information and the other, the organisation and conduct of experimental investigations, which are usually undertaken by laboratories, etc., not under the direct control of the Association, such as those of universities and Government departments.

ELECTRIC POWER PLANT IN THE UNITED STATES.

On Wednesday, February 4, at a meeting held in the James Watt Institute, Birmingham, Mr. F. W. Lawton, M.I.E.E., chief engineer and manager of the Birmingham Corporation Electricity Department, who has been President since 1939 of the Midland Section of the Junior Institution of Engineers, inducted as his successor Mr. L. F. Jeffrey, B.Sc., M.I.C.E., chief engineer of the West Midland Joint Electricity Authority. Mr. Jeffrey then delivered his presidential address, consisting of his "Impressions of Power Plant Development in the United States," during a recent tour which embraced New York, Philadelphia, Washington, Chicago, Detroit and Boston. All of the numerous power stations visited, Mr. Jeffrey said, were situated on rivers; none used the cooling towers which evoked such criticism on æsthetic grounds in England, though in other respects, he thought, less attention was paid to architectural appearance than in this country. In some areas, what he described as a "voluntary grid system" was in successful operation, a number of large stations, aggregating perhaps 3,000,000 kW or more, and under independent ownership, being linked by high-tension lines and controlled as a group. Slag-tapped boiler furnaces were in fairly general use, and could be employed with advantage because of the consistent quality of the coal supplied to the stations; the price of the coal was about the same as that paid by British stations. Hydrogen-cooling of alternators, first proposed in 1921, was a common practice. In large cities, Mr. Jeffrey continued, the current consumption by air-conditioning plants was imposing a considerable extra load on the power stations; in Washington, for instance, it amounted to some 75,000 kW and caused the average total summer load to be greater than the average winter load. Service to the consumer, by the electric-power distributors, was of an increasingly high order, and

was even carried to the length of operating a private broadcasting station from which reports of faults, received at the station by telephone or otherwise, were passed to wireless-equipped service cars, patrolling the supply area. There was a distinct trend towards a greater standardisation of generating plant, such as was made compulsory in the United Kingdom by a recent Order of the Ministry of Fuel and Power. The address was followed by the presentation of a colour film, taken during the tour by Mr. Garnet Peirson, M.I.E.E., also of the West Midland Joint Electricity Authority.

LETTERS TO THE EDITOR.

WIRELESS DIRECTION FINDING.

To the Editor of Engineering.

SIR,—The review, on page 76 of your issue of January 23, 1948, of the new edition of Mr. R. Keen's book on *Wireless Direction-Finding*, displays an example of current needs calling forth the same solution from various brains independently, but nearly at the same time. With the increasing need for science in the Defence Services, it may be of interest to your readers to know that the discovery in 1939 of systematic errors in high-frequency D/F bearings was made by an officer of the Royal Navy, who had not the advantage of any specialised resources beyond the general knowledge expected in the military, or executive, branch. The principle gave correct and important results in that and succeeding years, and, while error-variations and probability-sectors were being assigned to direction-finding stations with increasing confidence, similar phenomena and conclusions came, in 1941, to the notice and attention of Major Keen, as he then was, and whose book, as noted in your review, was already well known.

By 1942, similar data had led to the same result also in the United States, where, with characteristic attention to instruments, graduated sectors of light were used in plotting, to represent the error-spread and reliability-factor of each station, even before the principle itself was fully accepted in Whitehall. So elusive were the factors involved, that inter-Service co-operation long awaited enough data for discussion, and as late as 1942 a high authority attributed the results in part to intuition. Even to-day the calculation of probability requires a flair for detecting non-systematic errors. The man matters more than the analytical instrument.

Yours faithfully,
H. S. GUERRIER, Cdr., R.N.

2D, Carlisle-place,
Westminster, London, S.W.1.
January 27, 1948.

FLOW OF BOILING WATER THROUGH NOZZLES, ORIFICES AND PIPES.

To the Editor of Engineering.

SIR,—Many engineers will be indebted to you for publishing an abridged form of the most interesting paper on "The Flow of Boiling Water through Nozzles," presented by Mr. J. G. Burnell to the Australian Institution of Engineers. Until this appeared, the discharge rates for saturated water through nozzles revealed by the tests reported by Bottomley in England and by Benjamin and Miller, as well as Stuart and Yarnell, in the United States, were badly in need of confirmation. Mr. Burnell now provides such confirmation over a pressure range of 170 lb. per square inch, together with a neat theory (based on Bottomley's work) which closely checks with the experiments. This work has important applications in mechanical and chemical engineering, and the results of these investigations can now be applied with confidence.

It is, therefore, a little surprising to find that Dr. R. S. Silver should wish to depreciate the value of Mr. Burnell's paper in his letter published on page 616 of your issue dated December 26, 1947. While Dr. Silver's own contribution to this subject, in collaboration with J. A. Mitchell, was valuable inasmuch as it comprised tests on nozzles of varying length, it was limited to a pressure range of only 35 lb. per square inch. Coupled with this was an unconfirmed theory assuming the evaporation of water in a nozzle at a finite rate, which is contradicted by simple experiments on the explosive expansion of static superheated water as well as by the experiments reported by Mr. Bottomley in his recent paper to the Institution of Mechanical Engineers.

Yours faithfully,
T. F. THOMAS.
H. C. YOUNG.

Metropolitan-Vickers Works,
Trafford Park, Manchester.
February 2, 1948.

OBITUARY.

MR. C. D. TAITE.

WE regret to record the death of Mr. C. D. Taite, a pioneer in the field of electric power supply, which occurred at Bowdon, Cheshire, on Sunday, February 1, at the age of 75. Charles Davis Taite was born on December 30, 1872, and was apprenticed to Messrs. R. A. Scott, electrical engineers, Hammersmith, at the age of 17. After serving two years, however, he left, without completing his articles, to enter Faraday House, where he obtained a prize in electrical engineering at the end of the first twelve months. He then joined the staff of the Manchester Edison and Swan Company, but after a short time transferred to the Charing Cross and Strand Electricity Supply Corporation, and was later on the staff of Messrs. S. Z. de Ferranti, Limited. During his service with the latter firm he was engaged for some time on experimental work, but was subsequently in charge of the erection of generating plant at Portsmouth, Southport and other towns. In 1896, he was appointed electrical engineer to the borough of Southport, and, after serving in that position for five years, during which time considerable extensions were carried out to the generating station and the mains, and a tramway system was inaugurated, took up a similar post at Salford. This position he also held for five years until his appointment as engineer and manager of the Lancashire Electric Power Company at the beginning of 1907. He retained this position until his retirement in 1946, having been elected to the board as managing director a short time before.

The greater part of Mr. Taite's life was therefore bound up with the progress of one concern; and to appreciate his work something should be said about the role played in the development of electricity supply by the so-called "power companies," of which the Lancashire Electric Power Company, of course, was one. These bodies were formed in the early years of the century to implement the views expressed by the Cross Committee of 1898, that the conditions imposed by the Electric Lighting Acts of 1882 and 1888 were not appropriate where it was desirable that a bulk supply should be given over large areas. These companies were relieved from compulsory purchase, but were only allowed to supply electricity in bulk to authorised distributors or for power purposes. They were also precluded from supplying electricity in any area which already formed part of the area of an authorised distributor without the consent of that distributor. Progress was, therefore, naturally slow at first, and was only effected at the expense of a great deal of labour by energetic officials, such as Mr. Taite. Later, the spread of industry beyond municipal boundaries and the growing demand for electricity led to considerable improvement, so that at the time of his retirement the annual output of the company had risen to 716,233,098 kWh, compared with only 5,380,847 kWh forty years earlier.

Mr. Taite was elected an associate of the Institution of Electrical Engineers in 1897, and was successively transferred to the class of associate member in 1901 and to that of member a year later. He had served on the Council of that body and had been chairman of the North Western Local Centre. He had been also chairman of the National Consultative Committee of the Central Electricity Board and of the British Electrical Development Association. He had served as President of the Incorporated Association of Electric Power Companies and was a member of the Joint Industrial Council for the Electricity Supply Industry.

THE GAUGE AND TOOL EXHIBITION.

As briefly recorded in our last issue, the second Gauge and Tool Exhibition opened at the New Hall of the Royal Horticultural Society, Vincent-square, London, S.W.1, on Monday, January 26. When the Gauge and Tool Makers' Association staged their first exhibition two years ago, they were not only embarking on a new venture, but were also showing many original designs developed during the war. On this occasion, with a few notable exceptions, there is more evidence of improvements to established designs than of new developments. There are 82 exhibitors, showing gauges and measuring instruments, jigs and fixtures, press tools, moulds and dies, pneumatic and electric portable tools, diamond tools, a wide range of cutting tools and machines designed for special purposes. The Association invited the National Federation of Engineers' Tool Manufacturers to participate in the Exhibition. As in 1946, all stands in the hall have the same simple type of façade, which is well suited to an exhibition of small products, and is pleasing in appearance.

Messrs. Denfords Engineering Company, Limited, Box Trees Mill, Wheatley, Halifax, Yorkshire, showed several measuring instruments and small machine tools. The precision capstan lathe illustrated in Fig. 1, opposite, has been designed for turning components from bars up to $\frac{1}{2}$ in. in diameter, and is provided with collets for this purpose. It is driven by a $\frac{1}{4}$-h.p. electric motor, which can be supplied to run at either 1,425 r.p.m. or 2,850 r.p.m.; the former provides a range of eight speeds from 180 r.p.m. to 2,100 r.p.m., and the latter a range of eight speeds from 360 r.p.m. to 4,200 r.p.m. Two belts transmit the drive, and the headstock is enclosed at the front. The spindle runs in Timken taper-roller bearings, and is screwed to take a 4-in. chuck. It is bored to a diameter of $\frac{33}{64}$ in., and the collet is opened and closed by a rotary movement on the lever at the end of the headstock. The turret has six stations, and is mounted on a top-slide which has a traverse of $3\frac{1}{4}$ in. The maximum distance between the spindle nose and the turret face is 12 in. The cross-slide is operated by a lever, and has a maximum traverse of $3\frac{3}{4}$ in. It is fitted with two tool-posts, the maximum distance between which is 4 in. The lathe incorporates a friction clutch operated by a pedal, which leaves the operator's hands free for changing the work-piece, etc. A bar-feed mechanism and stop can also be provided. The maximum swing is $6\frac{7}{8}$ in. over the bed and $2\frac{7}{8}$ in. over the cross-slide. The overall length of the bed is 30 in., oud the total weight of the lathe and motor is approximately 275 lb.

Two other new machines were shown on Messrs. Denfords' stand: a $4\frac{1}{2}$-in. screw-cutting lathe, and a 5-ton press. The lathe is provided with a graduated compound slide-rest, a 12-speed back-geared headstock (with a belt drive generally similar to that on the capstan lathe already described), and a $\frac{1}{2}$-h.p. motor. Automatic longitudinal and cross feeds are obtained by moving a tumbler lever. The length of the bed is 40 in., the distance between centres is 21 in., the spindle is bored $\frac{3}{4}$ in. diameter, and the maximum swing is $9\frac{1}{4}$ in. over the bed and $5\frac{1}{2}$ in. over the saddle. The design of the 5-ton press is unusual; the 70-lb. flywheel is mounted in the cabinet-like base of the machine, together with a 1-h.p. motor. The drive from the flywheel to a crankshaft in the upper portion of the press is transmitted by a Renold $\frac{1}{2}$-in. pitch duplex-roller chain. The press operates at 120 strokes per minute, and when the stroke is only $\frac{1}{8}$ in., a blow of 8 tons is delivered. The maximum stroke is $1\frac{1}{4}$ in., and the maximum distance between the ram and the table is $7\frac{1}{2}$ in. The ram is drilled with a 1-in. diameter hole to accommodate the tool, and the table is 15 in. by 10 in. The press is 5 ft. 3 in. in height, 1 ft. 10 in. wide and 2 ft. deep, and weighs approximately 900 lb.

A rotary table with optical indicator was exhibited on the stand of the Coventry Gauge and Tool Company, Limited, Coventry, who showed a range of their "Matrix" gauges, measuring instru-

EXHIBITS AT THE GAUGE AND TOOL EXHIBITION.

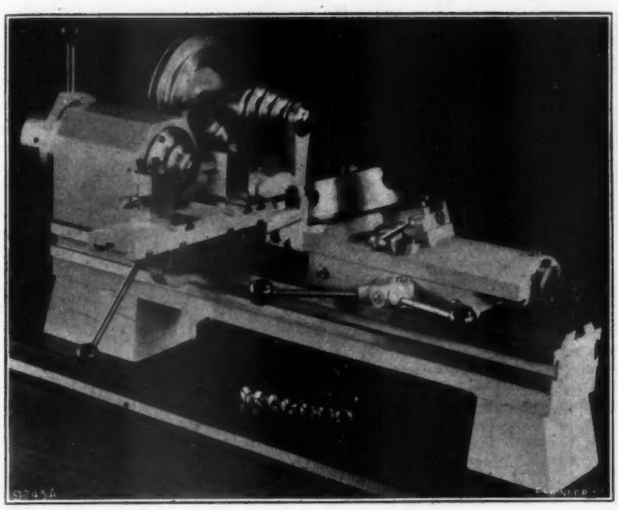


FIG. 1. PRECISION CAPSTAN LATHE; MESSRS. DENFORDS ENGINEERING CO., LTD.

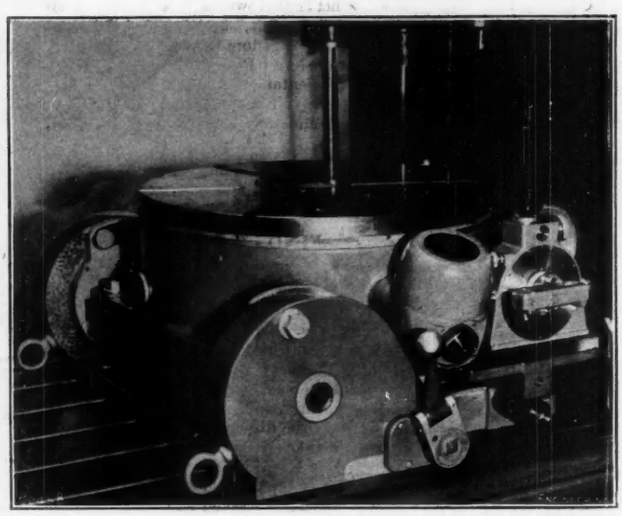


FIG. 2. INCLINABLE AND ROTARY TABLES; MESSRS. COVENTRY GAUGE AND TOOL CO., LTD., AND MESSRS. E. R. WATTS AND SON, LTD.

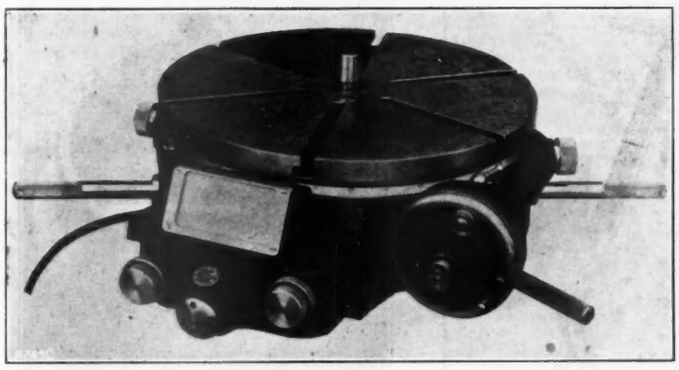


FIG. 3. 16-IN. ROTARY TABLE WITH OPTICAL INDICATOR; MESSRS. OPTICAL MEASURING TOOLS, LTD.

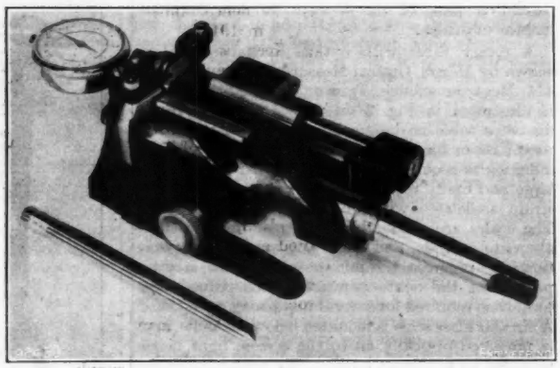


FIG. 4. TWIST-DRILL GAUGE; COVENTRY GAUGE AND TOOL CO., LTD.

ments, etc. It is a joint product with Messrs. E. R. Watts and Son, Limited, 123, Camberwell-road, London, S.E.5, and is shown in Fig. 2, on this page, mounted on an inclinable table manufactured by the Coventry Gauge and Tool Company, with a Watts "Microptic" precision clinometer. The rotary table, inclinable table, and clinometer can be used separately or in combination, as required, and in the latter case the overall height is much less than is usual with such combinations. The inclinable table may be tilted about its trunnions through 90 deg., from the horizontal to the vertical position. The movement is effected by rocking the small lever shown in the foreground of Fig. 2. This operates a ratchet-driven shaft, which extends across the full width of the base and is fitted with a worm wheel at each end to elevate the table. This arrangement ensures that the table is supported at both sides, and is therefore not subjected to distorting forces. A protractor scale is incorporated, but for more accurate setting the clinometer or angle slip gauges are used. The table is provided with three T-slots and is locked in position by a nut on each side and slotted locking strips. The height to the top surface of the table when it is horizontal is 4½ in., and the table measures 25½ in. by 24 in.

The inclinable table may be set to within an angle of 3 seconds by means of the Watts precision clinometer, which is shown on the right of Fig. 2. The body is mounted on a lapped steel base, and houses a 360-deg. glass circle and a finely-ground steel bearing. Inclination is measured by levelling the bubble and reading the angle through the eyepiece. Centring errors are eliminated by the design of the instrument, the operator observing the mean of two readings at diametrically-opposite points on the glass circle. For measuring angles in the horizontal plane the spirit level and its mount may be replaced by a mirror, and the instrument used in conjunction with an auto-collimator. It is laid on its back, on three supports provided in the body.

The 18-in. circular dividing table is fitted with an illuminated ground-glass screen for observing the rotation of the table to within 3 seconds. The projection system in the body of the table is a sealed unit protected from dust and oil, and from the heat of the scale-illuminating lamp, the light entering the system through a window of heat-resisting glass. The viewing screen is 3 in. in diameter, and is protected by armoured glass and a metal hood. The optical micrometer is controlled by a milled knob on the screen housing. The top surface of the table is finished flat to within 0·0001 in. by lapping, and is parallel to the base to within a similar tolerance. The table is rotated by a worm drive, spring-loaded to eliminate backlash, and provided with a cam for disengaging it. There is a fine adjustment in addition to the handwheel. The rotating table is carried on steel balls on a large-diameter circular track, and is locked by moving a lever which applies equal pressure to two clamps; these grip a flexible disc carried on the rotatng table. Four telescopic lifting handles are provided.

The "Matrix" twist-drill gauge was also shown on the stand of the Coventry Gauge and Tool Company, Limited, and is illustrated in Fig. 4, on this page. It is used for checking the angles and concentricity of the point of a drill—factors which affect the size of the hole drilled, and the life between successive sharpenings of the drill. The illustration shows a large taper-shank drill resting in the left-hand V-way for checking the angles. The drill is held lightly on the V-way by pressing with one hand on the hinged steady-bar on top of it, and it is then rotated slowly with the other hand. Each cutting edge in turn bears on a small vertical plate pivoted about a vertical axis, and causes it to rotate to conform with the angle of the cutting edge. The outer scale on the dial shows the variation from standard to within 0·25 deg. The angle gauge is set to zero for a standard drill angle of 59 deg. (or for any other required angle) by means of a setting rod shown in the foreground of Fig. 4. The test for concentricity of the point is made with the drill in the right-hand V-way, with a hinged steady-bar held as before. The point of the drill is held lightly against a stop (the position of which may be adjusted to give a zero reading on the inner scale, when a particular size of drill is being tested), and as the drill is rotated each cutting edge in turn bears on a knife-edge of a lever member, which actuates the indicator. It is important in this test to ensure that the drill rests solidly in the V-way. Any error is shown by a difference in the minimum readings for each cutting edge, and represents the amount in thousandths of an inch to be removed from one edge to ensure

EXHIBITS AT THE GAUGE AND TOOL EXHIBITION.

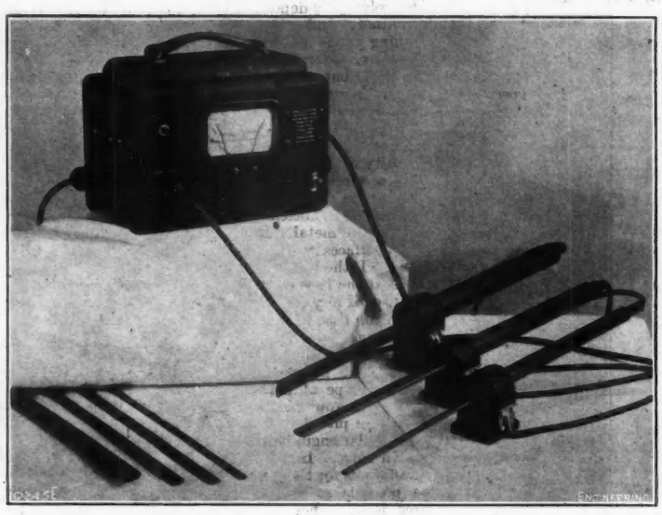


Fig. 5. Electronic Comparator; Messrs. A. C. Wickman, Ltd.

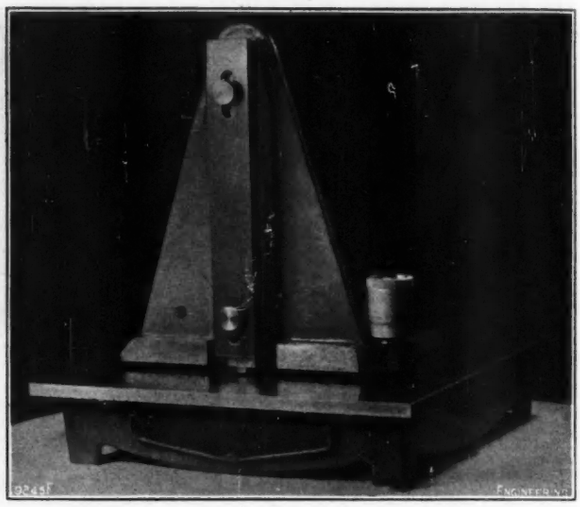


Fig. 6. Square-Testing Stand; Messrs. Windley Brothers, Ltd.

concentricity. The gauge is provided with an extending part of the V-ways to suit different lengths of drills.

A rotary table with optical indicating dial is shown by Messrs. Optical Measuring Tools, Limited, 414, Montrose-avenue, Trading Estate, Slough, and is illustrated in Fig. 3 on page 137. This 16-in. diameter table is designed for use with jig-boring machines, or for any work in which accurate rotary indexing is required. The illuminated indicator is large and easily read, and does not impose the eye strain associated with microscope-type indicators. The scales are graduated in degrees, minutes and alternate seconds, and while one machining operation is in progress, the minute-second scale may be pre-set for the next operation. This reduces the total time required for several machining operations. A circular glass scale is mounted below the table, and is projected optically on to the screen, light being provided by a 12-watt bulb. Two graticule images are also projected on to the screen, for reading degrees, minutes and alternate seconds. A knob on each side of the screen is used for setting the minute scale and an indicator line. The table is locked by the knurled knob shown on the right of the illustration, and removable handles are provided for lifting. A worm-and-wheel two-speed hand drive is fitted, and wear in these components does not affect the accuracy of the indicator. A tapered setting plug, which rotates within 0·0002 in. of concentricity with the table, is supplied, and the surface of the table is parallel to within 0·0002 in. of the base surface, at all rotary positions of the table.

The Cornelius electronic comparator is among the exhibits of Messrs. A. C. Wickman, Limited, Tile-hill, Coventry. The object of this instrument, which is operated from the 230-volt 50-cycle mains, is to enable the dimensions, hardness, chemical composition, surface finish and other properties of a work piece to be compared with those of a standard sample, any difference being shown by the movement of an indicating needle. As demonstrated, the standard is first placed in or against an "adaptor" connected to the instrument, the needle of which is then set at zero by means of two controls. On replacing the standard by the part to be examined, the needle will be deflected unless the part is identical in all respects with the standard. The instrument, which is illustrated in Fig. 5, on this page, comprises a valve oscillator the frequency of which is modified by the characteristics of the circuit containing the adaptor. These, in turn, depend upon the properties of the part in the adaptor, and the instrument having been adjusted to those of the standard, any variation in the corresponding properties of the part inserted subsequently will cause a deflection of the indicating needle. Adaptors are provided to suit different classes of work, and can be plugged into the instrument as shown in Fig. 5. One adaptor is in the form of a short cylindrical coil; the insertion, in turn, of two apparently similar metal bars produced a small deflection of the meter needle in one case, and a large deflection in the other, the difference being due to a small crack in one of the bars. The instrument appears equally sensitive when an adaptor is placed on flat metal rings in order to indicate the degree of their surface finish. In effect, the surface finish creates different lengths of air gap between the rings and the adaptor, so that different meter readings are obtained in each case. It is claimed that the instrument is equally suitable for detecting small changes in composition as well as dimensional changes, being, for example, particularly sensitive to the nickel content in steel. When set up, say, for inspecting steel bar, the changes in meter readings may therefore be due either to composition or to dimensional variations. It is understood, however, that, with experience, an operator can recognise certain types of flaw by the nature of the meter deflection, and that material can be passed, provided these deflections remain within certain prescribed limits.

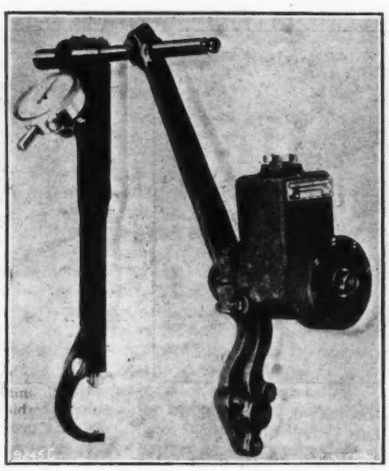


Fig. 7. Grinding Gauge; Messrs. M.P.J. Gauge and Tool Co., Ltd.

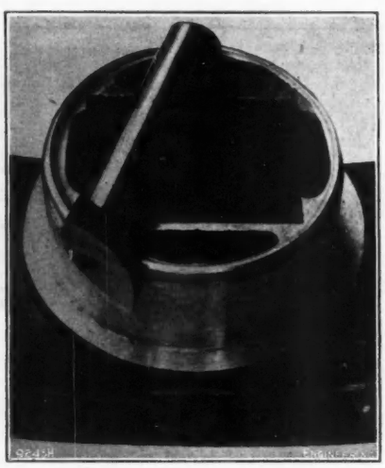


Fig. 8. Cutter for Rectangular Holes; Messrs. W. E. Sykes, Ltd.

Messrs. Windley Brothers, Limited, Crown Works, Chelmsford, Essex, show a number of surface plates and tables, straight-edges, magnetic chucks, etc. There are also a compound-angle magnetic sine table, and a try-square testing stand, which is illustrated in Fig. 6, on this page. It consists of a surface plate, on which is a straight-edge held in a vertical position by a frame, which may be tilted slightly to either side by a micrometer fixed to one arm of the frame and bearing on the surface plate. The micrometer is graduated to 0·0001 in. The square to be tested is placed with its stock resting on the plate, and its blade touching one vertical edge of the straight-edge, which is adjusted to ensure contact. On transferring the square to the other side of the straight-edge, and adjusting the micrometer, a measurement corresponding to twice the error is obtained.

A novel method of testing screw threads is incorporated in the "O-Vee" Screw Thread Comparator, manufactured by Messrs. O-Vee Spring Gauges, Limited, Station-road, Edgware, Middlesex, and exhibited on the stand of Messrs. J. E. Baty and Company, Limited, 39, Victoria-street, London, S.W.1. The bolt, or similar screwed component, is gauged between two helical springs, which are fitted loosely, each over one of two short rods. The rods are parallel to each other, and the distance between them is adjusted to suit the diameter of bolt by

moving one away from, or towards, the other, and clamping it in the desired position. Movement of the other rod actuates a pointer over a graduated scale. The diameter of the bolt threads is gauged by allowing the coils of the springs to fit in the threads of the bolt, the points of contact of the two springs with the bolt being diametrically opposite, and the springs being pressed against the rods. The principle is similar to that in which three wires are used, but in this case the several coils of two helical springs function. The comparator provides a check on the pitch diameter of a bolt, and it is set by inserting standard block or slip gauges between the springs, and moving the adjustable rod accordingly. The thickness of gauge is equal to the nominal diameter of the bolt less a constant which depends on the diameter of the spring wire. The instrument is supplied with sets of springs to suit different numbers of threads per inch, and two models are available, for ¼-in. to 1-in. bolts, and for ½-in. to 4-in. bolts.

Messrs. M.P. J. Gauge and Tool Company, Limited, Hansons Bridge-road, Erdington, Birmingham, 24, show a range of gauges for special purposes. That illustrated in Fig. 7, opposite, is designed for observing the size of a cylindrical component while it is being ground in a machine. The measuring system is shown on the left of Fig. 7. The lower C-shaped caliper fits over the workpiece, and makes contact with it at three points by means of a lower, a middle, and an upper anvil; the caliper is free to move vertically against a spring and actuate the indicator. The measuring system is supported on an arm of a car-type hydraulic shock absorber which is fixed to the grinding machine. In its free position it remains elevated clear of the workpiece, but when the operator requires to check the size of the piece he pulls the gauge down against the resistance of the shock absorber, and clips it over the piece, which is allowed to continue in rotation. The upper and lower anvils pass the maximum diameter of the work slightly before the middle anvil bears. This, however, does not affect the function of the gauge, since it is set to zero for each job by clipping it over a standard plug gauge in a similar manner. The gauge is suitable for diameters from ½ in. to 8 in., and a range of fixed or adjustable calipers is available for this purpose. A dial indicator having graduations of 0·0001 in., 0·0005 in. or 0·01 mm. is supplied. The anvils are tipped with tungsten carbide.

Among the gear-cutting equipment is an interesting type of forming or slotting too, demonstrated by Messrs. W. E. Sykes, Limited, Staines, Middlesex, for cutting and finishing rectangular holes. A photograph of the tool and the type of work for which it is suitable, or can be adapted, is reproduced in Fig. 8, opposite; this shows a rectangular hole that has been cut in an aluminium casting by the slotting action of the cutter. The design of the tool and the set-up of the work are based on the properties of rolling surfaces, and the profile of the cutting edges is two intersecting arcs, the radii of which depend on the lengths of the sides to be formed. In the demonstration, downward cutting strokes were made as the tool and work rotated slowly in the same direction about vertical axes passing through the hole being cut. The tool and the finished hole may be regarded as special forms of gear teeth, since the profile of the cutting-edge "rolls" round the sides of the completed hole during the final stage, the intersections of the two cutting faces engaging in turn with the four corners of the rectangle. The profile of such tools can be ground to suit holes of various shapes, such as, hexagonal holes. In each case, however, the work must be located and the speeds of rotation adjusted to ensure the correct "rolling" action and the required hole contour during the finishing strokes. Any alteration in the cutting profile, such as that caused by wear, will affect the final shape of the finished hole. It is claimed, however, that certain tolerances are permissible, and that a long production run can be carried out. The tool appears to be particularly suitable for forming blind holes of special section, or for cases where broaching might cause distortion of the metal.

The Gauge and Tool Exhibition closes to-day, Friday, February 6, at 7 p.m.

POROUS-CHROMIUM HARDENING OF DIESEL-ENGINE CYLINDERS.*

By C. D. B. WILLIAMS.

SOME years ago, when the hardness and corrosion-resisting properties of chromium were realised, it seemed that hard chromium deposited on the bores of internal-combusion engine cylinders would help to overcome cylinder-bore wear. Early experiments, however, met with little success as at that time the general tendency was to give cylinder bores a mirror finish; such a finish was given to early chromium-plated cylinders, which resulted in piston and piston ring seizures. A Dutch engineer, H. van der Horst, who was working on this problem, believed that the fundamental cause of the seizures was poor lubrication brought about by the inability of chromium to retain oil. With this in mind he evolved a process whereby a hard chromium surface could be produced which was covered with pits and depressions suitable for retaining the lubricant. This type of surface was successful in widely varying types of engines and has been used since to an increasing extent. During the last few years considerable research has been carried out by other investigators in an endeavour to find a process to supersede that of van der Horst, but although many interesting and satisfactory results have been obtained, most investigations have been based on the original theory and, so far as the author is aware, the results obtained by the van der Horst methods are still the most satisfactory.

The causes of cylinder-bore wear are many and opinion is divided on this controversial subject. It is reasonably well agreed, however, that the main causes are abrasion, corrosion, bore distortion, indifferent fuel, inadequate lubrication, bad combustion, over-heating, detonation, crankshaft vibration and bad crankcase ventilation. In the author's opinion, bore distortion is the cause of more bore wear than is generally realised; it is essentially a problem of design, however, and no bore material can overcome a fundamental fault of this nature. So far as the other causes of bore wear are concerned, abrasion and corrosion embrace most of them, and chromium is the one material particularly resistant to both these conditions as found in the bores of internal-combustion engines. Chromium with a Brinell hardness of 800-1,000, depending on the method of deposition, is little harder than other known cylinder bore materials and, from the point of view of abrasion, may not be much better than the next best material; but the qualities of corrosion resistance, high thermal conductivity, and low coefficient of friction are better than for otner materials. Corrosion is considered by many authorities to be the major cause of bore damage, particularly in these days of poor quality fuel and often adverse operating conditions. Chromium is unaffected by practically all the usual corrosive products encountered in a heavy-oil engine, but is attacked slightly by sulphuric acid, and in some circumstances the small amount of sulphur present in Diesel fuels may combine with products of combustion to form dilute sulphuric acid. The effect of this acid on chromium, however, is small, whereas the vigour with which it attacks ferrous cylinders is considerable.

At this stage it may, perhaps, be opportune to mention that chromium must not be run on chromium, or seizure is inevitable. Furthermore, piston and piston-ring clearances should never be reduced with chromium-hardened bores; in fact an increase of some 20 per cent. in these clearances usually is beneficial, as the high rate of wear which takes place during initial running with cast-iron bores does not occur with chrome-plated bores.

The main feature of the van der Horst method of bore plating is the provision of a chromium surface having the necessary porosity to hold lubricating oil, thus preventing seizure and at the same time reducing wear. With such a surface, remarkable results have been obtained in service and increased bore lives of from 200 to 1,000 per cent. have been recorded, together with reduced piston and piston-ring wear. An important point in connection with porous chromium is that the type of porosity should be suitable for the class of engine in which it will be used. There are two main types of porosity, usually known as the channel type and the pitted or cokey type. In the channel type the surface is broken up into a series of small plateaux, interspersed with cracks or channels running in various directions, whereas in the pitted type the plateaux are few and small while the depressions are both wider and deeper. The whole surface has a more broken appearance and resembles, to a great extent, the surface of a piece of coke. Within these main types of porosity the surface can be varied considerably so far as the percentage of porosity is concerned. Porosity is produced mainly by a reverse-etch treatment after plating and the type of porosity is controlled largely, but not entirely, by the length and severity of the etching process. During etching the microscopic cracks, indicative of residual stresses normally present in electrolytically-deposited chromium, are attacked preferentially and are widened and deepened as the etching proceeds. During the early stages fairly large plateaux, interspersed by narrow shallow channels, are seen, but after further etching these plateaux are broken down into progressively smaller plateaux as the etching proceeds until plateaux, as such, cease to exist, and from this stage a gradual removal of the entire surface takes place. The average depth of true porosity is from 0·002 in. to 0·004 in.

In connection with the depth of porosity, it is necessary to be quite sure that the skin thickness of the chromium is sufficient to ensure that no porosity extends to the base metal. It is also necessary to inspect carefully surfaces to be plated for the existence of blow holes. If the base metal is exposed and oxidation takes place at the base of the blow hole before the cylinder is used, or if any reactive product of combustion should reach the base metal, there is the danger of exfoliation occurring.

Apart from the depth of porosity, the percentage of porosity to plateau area is important. Usually the channel type of porosity is used for aircraft engines having narrow piston rings with high unit loading, while the pitted type of porosity is used for heavy-oil and similar engines with wider and more lightly-loaded piston rings. In the author's opinion, the ideal state of affairs is for the percentage of porosity to be as great as possible so long as the plateau of load-carrying area is of sufficient strength and area to carry the load imposed by piston and rings without wear taking place. It should be mentioned that although the melting point of chromium is about 300 deg. C. higher than that of cast iron, chromium softens to an appreciable extent at a comparatively low temperature. It is wise, therefore, to keep the cylinder-wall temperatures reasonably low if the best results are to be obtained.

It is necessary for the surface being plated to be prepared properly and of satisfactory structure, and great attention to detail is necessary in the cleaning and preparation for plating and in the plating itself. Although almost all cast irons and steels can be plated satisfactorily, a good deal of work has been carried out during the last ten years to produce a range of cast irons particularly suitable for porous-chromium plating. It is the usual practice to hone cylinder bores before plating, a process which gives the most satisfactory surface. The action of honing is better for the base metal than either machining or grinding, as both these processes can produce a distorted surface layer having high internal stresses, the release of which can cause exfoliation. In connection with adhesion it should be mentioned that all sharp corners must be removed from the ends of cylinders, port edges, connecting-rod cutaway, etc., before plating. There is always a tendency for build-up to occur on sharp corners and this can cause trouble either when honing, or if the edge should be inadvertently knocked during transit, when a piece of the chromium probably will break away. Recently, comment has been made regarding the possibility of adhesion troubles arising from the different linear thermal expansion of chromium and cast iron, but in the author's experience this has never caused trouble.

Honing a porous-chromium-plated cylinder bore is an exceptionally skilled operation. Honing an ordinary bore calls for dimensional accuracy only, but honing a plated bore requires not only dimensional accuracy but correct porosity of the surface as well, and neither requirement must be sacrificed to the other. For this reason, rather wider dimensional limits usually are allowed with chromium-hardened bores. Dimensional inspection, and inspection for build-up on corners of plated bores, is carried out in the normal way, but surface inspection has been given considerable thought. Nowadays the profilometer is used extensively for surface measurements but, excellent as this instrument undoubtedly is for some purposes, it is unsatisfactory for use on porous chromium. The most satisfactory method of inspection seems to be visual comparison under low magnification with micro-photographs of surfaces known to be satisfactory.

Types of cylinders recently chromium-hardened include marine-engine liners, locomotive cylinders, commercial vehicle and private motor-car cylinder blocks, and aircraft cylinders. The following figures, which have been taken at random from performance records, give an indication of the results obtained: on a Diesel-engine liner having a bore of 350 mm. after plating the wear was 0·0002 in. per 1,000 hours running, while on a cylinder block of a Diesel engine fitted to a standard commercial vehicle, the wear was reduced to 0·002 in. for 100,000 miles. On a small marine auxiliary engine, plated liners were run in direct comparison with unplated liners, and at the end of the test, the plated liners had worn 0·002 in., whereas the unplated liners had worn 0·020 in.

* Paper read at a meeting of the Diesel Engine Users Association, held in London on January 15, 1948. Abridged.

CATALOGUES.

Economisers.—A catalogue published by Senior Economisers, Limited, 11, Southampton-row, London, W.C.1, describes the principles of economisers, and illustrates typical installations. There are three main types: the Senior Twintube economiser, the Senior welded economiser, and the Senior H-tube economiser.

Cooling-Water Plant.—A booklet received from The Visco Engineering Company, Limited, Stafford-road, Croydon, contains illustrations and descriptions of evaporative water coolers, including natural-draught and forced-draught plants. A section giving meteorological information on many places throughout the world is included.

Transparent Machine Guards.—The Silvaflame Company, Limited, 218A, Monument-road, Birmingham, 16, manufacture the "Clearvue" guards for machines, and these are described in a series of leaflets. They include guards for drilling machines, and vertical and horizontal milling machines, and are provided with Perspex sheet to facilitate the work of the operator.

Drying Plant.—A wide variety of drying plant is described in a booklet received from Messrs. Musgrave and Company, Limited, St. Ann's Ironworks, Belfast. The principal types are conveyor, tunnel, chamber, compartment and table driers, and they are used for many classes of work, including textiles, foods, building materials, paints, vitreous enamelling, timber, rubber, etc. Some useful information on the physics of drying is included.

Lacing Machine for Conveyor Belts.—An improved type of "Comet" conveyor-belt lacing machine, particularly suitable for collieries, is described in a leaflet issued by the Mastabar Belt Fastener Company, Limited, Cleckheaton, Yorkshire. The weight of the machine is 38 lb., compared with 46 lb. for the previous design, and it is provided with an improved handle and a short comb. The leaflet also describes an appliance for cutting the end of a belt square.

Diaphragm Valves.—The range of diaphragm valves manufactured by the Saunders Valve Company, Limited, Cwmbran, Newport, Mon., is described in a pamphlet issued by the firm. The valves may be controlled by means of a handwheel, lever, chain wheel, piston and cylinder, or air motor (for remote control). The bodies of the valves are made in a variety of shapes, of cast iron, malleable iron, bronze or gunmetal, and may be lined with rubber, glass or lead to suit different liquids.

Roll-Grinding Machines.—The construction and uses of roll-grinding machines are well illustrated and described in a catalogue received from the Churchill Machine Tool Company, Limited, Broadheath, Manchester. There are two main types: those in which the roll is traversed past a fixed grinding-wheelhead, and those in which the wheelhead traverses along the roll. The machines are fitted with swarf separators and Hydrauto bearings, and are generally provided with a cambering mechanism.

Ventilating Fans.—The electric fans and associated equipment manufactured by Messrs. Musgrave and Company, Limited, St. Ann's Works, Belfast, are described in a booklet received from the firm. They are made in sizes from 9 in. to 72 in., the larger sizes being fitted with aluminium impellers. Flameproof fans, wire guards, butterfly shutters and wind shields, louvre-type shutters, cowls and grilles are also supplied. The booklet gives some practical advice on the layout of fans.

Spraying Equipment.—A complete range of equipment for applying sprayed finishes is described and illustrated in a catalogue received from the Aerospray Manufacturing Company, Limited, 1, Victoria-street, London, S.W.1. The spray guns, etc., are suitable for paint, vitreous enamel, plastic paints, paints containing large cork particles, anti-drumming compounds, oils, insecticides, etc. The auxiliary equipment includes containers, valves, filters, automatic and semi-automatic plant.

Industrial Fittings for Fluorescent Lamps.—Details of industrial fittings for 40-watt 4-ft. fluorescent lamps are given in a catalogue issued by Philips Electrical Limited, Century House, Shaftesbury-avenue, London, W.C.2. The range covered consists of three single-lamp and three two-lamp units, each of which is supplied complete with power-factor apparatus, lampholders and starter holders, and is wired ready for use. The fittings consist essentially of a rectangular steel channel, in which the apparatus is housed and which is designed for three different suspensions.

Punching and Shearing Machines.—A wide range of machines for punching, shearing, notching, bending, cropping, splitting and nibbling is described in a catalogue received from Messrs. F. J. Edwards, Limited, 359-361, Euston-road, London, N.W.1. Punching, shearing, cropping and notching machines are available in hand-operated or motor-driven forms, for mounting on a bench, on a concrete foundation, or on wheels. There are combination angle-iron notching and bending machines, and the types of bench shearing and punching machines are particularly varied.

LABOUR NOTES.

SPEAKING at the annual meeting of the Birmingham Branch of the National Union of Bank Employees, last week Mr. C. R. C. M. Hammond, the national President, said that whereas organised manual workers had received wage increases of between 70 and 75 per cent. since 1939, salaried workers had received nothing comparable with that amount. Yet the cost of living had increased greatly—in some cases, by more than 100 per cent. The union, he recalled, had warned bank staffs in 1946, when consolidation was introduced by the company unions, that economic conditions were in a state of flux, and that prices would rise sharply. Developments had proved, he claimed, that the union's forecast was perfectly correct. The grave financial position of bank employees was due, Mr. Hammond declared, to their failure to organise solidly in a trade union. Bank employees in Eire were so organised, and as a result, they had secured an agreement giving them considerable advantages.

The Council of the Textile Institute has adopted a resolution expressing concern at "the continued failure of Government departments to recognise the qualifications of textile technologists." In the course of a statement on the subject issued last week, the Council said it had learned that the scientific and technical staffs of various Ministries were being divided into pools of qualified men, but that although scientists, engineers, and chemists were included in the categories, no provision was made for textile technologists, and the Central Register did not recognise the profession of textile technology. The Council decided, therefore, to invite the departments concerned to recognise the status of the textile technologist, and to draw attention to the qualifications of Fellows and Associates of the Institute under the terms and provisions of the Royal Charter.

Voluntary absenteeism among miners at the coal face, during the week ended January 17, was 7·58 per cent., and involuntary absenteeism, 5·91 per cent. The corresponding figures for the week ended January 10 were 7·24 per cent. and 5·83 per cent., and those for the week ended January 18, 1947, 10·71 per cent. and 8·73 per cent. Mr. Isaacs, Minister of Labour and National Service, stated in the House of Commons last week, that coal-mining was the only industry for which employees' absenteeism figures were available. That, generally speaking, had been the position for many years. Miners, he added, had often complained of the lack of comparison with other industries.

The Ministry of Labour and National Service reports that up till January 17, a total of 37,512 European voluntary workpeople (27,668 men and 9,844 women) had arrived in this country. Of these, 33,944 (24,439 men and 9,505 women) had been placed in employment by that date, while 2,095 were under submission for vacancies. The remainder, consisting of recent arrivals, were earmarked for vacancies which were in immediate prospect. European voluntary workpeople were placed mainly in agriculture (15,000), coal-mining (3,700), iron and steel industries (640), the main textile industries (7,100), and essential hospital and institutional domestic employment, including the running of the hostels in which the workpeople are accommodated (5,800). Smaller numbers were placed in other industries, including brick-making and quarrying, and in laundries and nursing.

Mr. A. G. Rouse, chief British delegate to the European Man-Power Conference, stated in the course of an interview in Rome last week, that Britain hoped to arrange, at the meeting, for the immigration, into the United Kingdom, of 100,000 foreign workpeople from among Europe's 2,000,000 surplus persons.

Mr. Isaacs, the Minister of Labour and National Service, in the course of a speech at the opening of a new Ministry staff training centre in London, said that since the Order authorising direction into essential employment came into force, the number of men and women who had had to be so directed was infinitesimal. When persons at employment exchanges were shown lists of essential jobs, there was no difficulty in persuading them to take one. The Ministry was not, Mr. Isaacs added, proceeding by force but on the principle that guidance was the better way—which was also the basic feature of the training scheme.

Representatives of the Transport and General Workers' Union and representatives of the new London Transport Executive discussed, on Wednesday of last week, the claims of the union for increased wages and improved conditions for members employed on omnibuses, trolley buses, and trams. Originally prepared for submission to the London Passenger Transport Board, the claim includes, it is understood, a demand for a minimum of 6*l.* 12*s.* a week for drivers and conductors in the central area. The conference—which lasted for about 10 hours—"failed to agree," and on the following day the Transport Executive formally reported to the Ministry of Labour and National Service that the claim was in dispute.

A pamphlet entitled "Industrial Democracy," published by the Labour Party, is described in an official statement from Transport House as "the first step in the preparation of a programme to put before the people at the next general election." The value of its contents as a lead to local labour groups and trade unionists is difficult for outsiders to assess, but, no doubt, it will be possible to do so with some degree of accuracy when the local "discussion groups" which the authors envisage, have answered "among others" certain "specific questions" which the pamphlet.

Among these "pertinent questions" are (1) Is employees' participation in control the next step forward towards industrial democracy? (2) How can joint production committees and similar bodies be given a new impetus in the privately-owned industries? (3) Should compulsion be adopted for all or only for some industries, or should we rely entirely on persuasion? (4) How should rank and file employees be kept in touch with joint committees? (5) In what way could joint consultation be developed for office employees? The replies to these "pertinent questions" are practically certain to be interesting, but, of their helpfulness to industry the ordinary citizen will probably be doubtful.

An Order issued by the Ministry of Labour and National Service shows minimum rates of wages which are to be paid to catering workers from March 1, together with holiday provisions and overtime payments. It applies to staffs of hotels, inns, holiday camps, licensed clubs with four or more bedrooms for guests, licensed restaurants, and licensed workers' hostels. Wages for a 48-hour week range from 7*l.* for a head waiter (5*l.* 10*s.* 3*d.* with full board and lodging) to 3*l.* 17*s.* for a barmaid and 4*l.* 10*s.* for a porter. All who were employed during the twelve months before the holiday season are to be given six days' holiday with pay, and those with two years' service are to have up to twelve days.

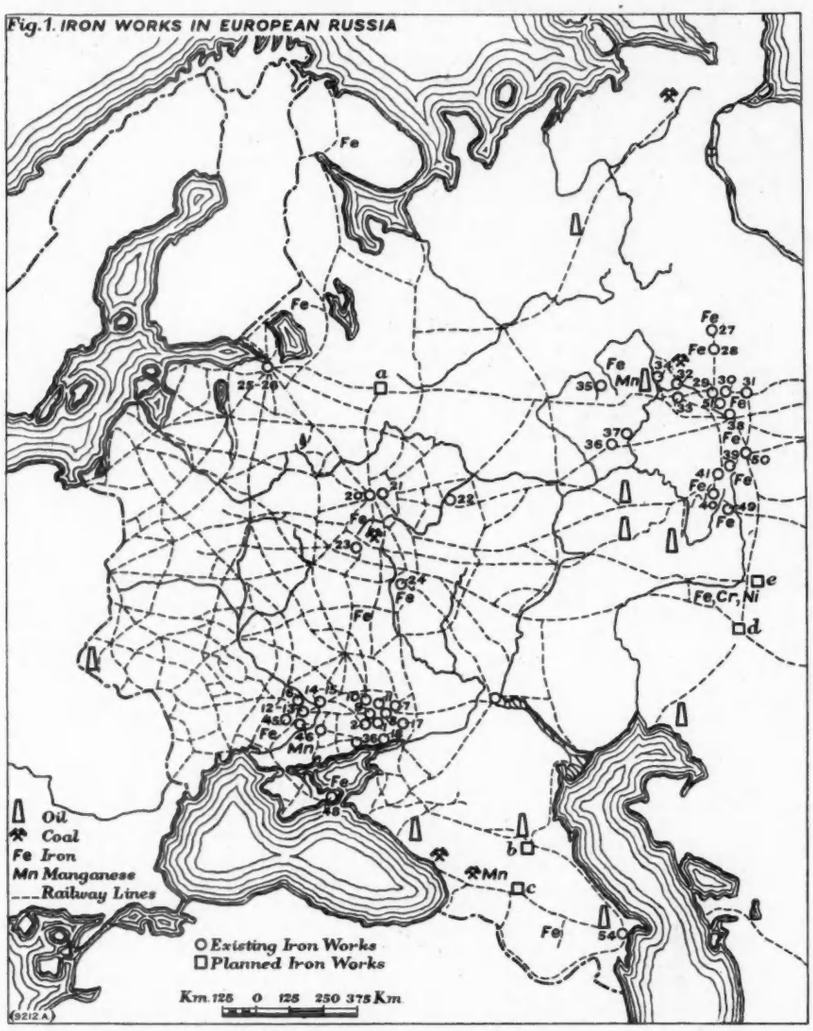
The lowest minimum for adult employees—the provision covers various classes—is 3*l.* 7*s.* 6*d.* (1*l.* 17*s.* 9*d.* with board and lodging). Extra waiters are to be paid 3*s.* an hour and extra head waiters 4*s.* an hour, and an addition of 25 per cent. will be paid in respect of night work. A full-time employee who works on a holiday will be paid treble time in lieu of a day off.

Mr. Isaacs told the House of Commons recently that since the Amalgamated Engineering Union still refused to accept Polish persons in the engineering industry, he had instructed officials of the Ministry of Labour and National Service to the effect that if no British persons were available and employers were agreeable, Polish workers were to be sent to engineering jobs in spite of the union's objections. It was necessary to do so, he said, in order to overcome the urgent labour shortage in some factories making equipment for coal mines and other vitally-needed machines. The executive council of the union has had the matter under consideration, but what the result of their deliberations will eventually be is difficult to tell. If the A.E.U. adheres to its decision not to admit Poles to membership, and Mr. Isaacs' area officials carry out his instructions, a situation will obviously be created which calls for rather delicate handling.

New wage scales for about 200,000 local government employees were announced last week, following an award of the National Arbitration Tribunal on claims made by the National Association of Local Government Officers. As from January 1, the scales for council staffs will consolidate all cost-of-living bonuses with basic pay. Thousands of "general division" typists and clerks—men and women—will receive increases of up to 25*l.* a year. For "general division" employees, the new scales for men will range from 135*l.* a year at 16 to 385*l.* at 32. The claim of the union was for 400*l.* at 32. Women's rates will be about 80 per cent. of those of men. In the "clerical division," scales will go up to 440*l.* a year.

Addressing Oxford University Socialists on Friday last, Mr. Arthur Horner, general secretary of the National Union of Mineworkers, said that steps would have to be taken soon that would result in a further increase in the price of coal, but, as the industry improved, coal would become cheaper.

IRON AND STEEL INDUSTRY IN RUSSIA.



THE IRON AND STEEL INDUSTRY IN RUSSIA.*

THE annual output of the iron and steel industry of Czarist Russia was slightly more than four million metric tons of pig iron and a similar amount of ingot steel. Due to the revolution, the output decreased to only 115,800 metric tons of pig iron and 147,200 tons of rolled steel in 1920. The plant was designed to use local fuel and cheap labour, and there was little mechanisation, which was another reason for the small output. Blast furnaces were very inefficient and had a high fuel consumption. The design of steelworks was based on English and German practice, the number of furnaces being small (at most, five or six in one shop) and ingots were cast in pits. Open-hearth furnaces were of small or medium size with a maximum charge of 70 tons†; heating was by gas, supplied by Siemens gas producers. All large works manufactured a wide range of products with uneconomical and insufficiently mechanised equipment.

Most ironworks in southern Russia were founded between 1890 and 1900, owing to extensive railway construction at that time. Maximum output was attained when the railways linked with Siberia, but stagnation set in after the Russo-Japanese war. It was not until shortly before the first world war that there was a revival of the Russian iron industry because of a new rearmament programme and the construction of strategic railways. A part of the industry was modernised according to American practice and, in 1912, Russian blast furnaces had the highest output per unit in Europe—50,000 tons a year; the output in Germany was 41,600 and in the United Kingdom 32,000 tons a year. The American annual output per furnace at the time was 80,000 tons, and therefore blast furnaces and other equipment were built to American designs and largely with American material. Little high-quality steel was produced, and the total production of steel in electric furnaces was only about 3,500 tons a year. The distribution of the iron industry in Russia is shown on the maps, Figs. 1 and 2, on this page and on page 142. At first the Soviet administration only reconstructed the old plants, and it took ten years to regain the 1914 output, as will be seen from Table I, herewith, and Fig. 3, on page 142. The figures for 1940, in the table were announced by Premier Stalin on February 9, 1946.

In 1929 and 1930, the industry was divided into three categories. The first consisted of the plants which were technically most advanced, which had sufficient space for expansion, and were favourably situated for the supply of raw materials; these plants were to be modernised and their capacity considerably increased. In the second category were the medium-sized plants, old-fashioned in their equipment, but having a useful production; here modernisation was suggested, but without the erection of new buildings. Thirdly, there were the small, badly situated and obsolete plants: here only rationalisation was proposed, involving little expense and merely intended to improve working conditions. Plans for new works were begun at the same time, and eventually the American designs, which were at that time the most advanced, were adopted. The plan for the Magnitogorsk plant was revised four times, and the proposed capacity increased from the initial totals of 656,000 tons of pig iron, 662,000 tons of ingot steel and 514,000 tons of rolled steel, to 4,500,000 tons of pig iron, 5,000,000 tons of steel and 4,000,000 tons of plates and sections. All new plants are designed for large outputs, with a maximum of mechanisation and the most efficient utilisation of fuel, raw materials, and by-products. To obtain maximum output and reduce operating costs, new plants were built to specialise in a narrow range of products; but, at the same time, care was taken that the combined output of the plants in any region would supply all the iron and steel needed in that region.

The size of an ironworks is determined by the output of the blooming mill. The Soviet rolling mills require 1·6 to 2 million tons of liquid steel a year, when fully employed. The new works in the Soviet Union are built for such an output; for example, a large plant like that in Magnitogorsk has two or three blooming mills, and its output is two or three times that of one of the standard-type new plants. In the remote parts of Russia there are smaller plants with a much wider production range, and this means a considerable saving of transport; they operated very satisfactorily during the war, when transport was a critical problem. These plants include equipment for the production of high-quality steels.

A basic requirement for expanding steel production was to increase the mining of ore and coal. This was achieved by increasing mechanisation, abandoning obsolete procedure and adopting up-to-date methods based on United States practice. For the smooth operation of blast furnaces of 1,000 to 1,300 cubic metres capacity, the ore has to be classified according to its chemical composition, physical properties, grain size, etc. A central ore-dressing plant was built, therefore, at Verehovcevo, where all the ores from the Krivoj Rog are classified and sent to the ironworks in Southern Russia. Several works were equipped with sintering plants and others are being similarly equipped. The coking industry has been developed entirely by Soviet technicians. Based on the results of extensive research work, a gigantic coal-washing plant was installed in the Donetz Basin and 85 per cent. of the coal used by the coke ovens of the Basin passes through it. The new coking plants supplied 80 per cent. of the coke production in 1937, and 76 per cent. of the coke was produced near the ironworks. In 1913, only 30·6 per cent. was produced in the proximity of ironworks. The coke-oven gases are utilised in the ironworks and the ovens are heated with the poorer blast-furnace gas. The new batteries usually have 50 to 60 ovens, and the coking time is 12 to 15 hours, instead of the 35 to 48 hours required in older installations. In all coking plants, the gaseous products of distillation are used. Coke of high purity is produced in the Donetz Basin and this is needed for the production of pig iron from the Krivoj Rog high-quality ores, which have a low phosphorus content.

TABLE I.—*U.S.S.R. Production of Pig Iron, Ingot Steel, Rolled Steel, and Tubes, 1913 to 1940.*
(Thousands of Metric Tons.)

Year.	Pig Iron.	Ingot Steel.	Rolled Steel.	Tubes.
1913 ..	4,216	4,230	3,506	67
1917 ..	2,964	3,080	2,444	*
1918 ..	597	402	357	*
1919 ..	116	119	179	*
1920 ..	116	194	147	*
1921-22 ..	180	318	259	10
1922-23 ..	314	615	473	22
1923-24 ..	670	993	690	49
1924-25 ..	1,309	1,868	1,390	75
1925-26 ..	2,203	2,911	2,250	112
1926-27 ..	2,961	3,592	2,743	132
1927-28 ..	3,282	4,251	3,408	171
1929 ..	4,320	5,003	3,836	189
1930 ..	5,017	5,863	4,570	232
1931 ..	4,871	5,614	4,085	284
1932 ..	6,173	5,922	4,288	310
1933 ..	7,133	6,835	4,906	*
1934 ..	10,428	9,693	6,734	*
1935 ..	12,489	12,400	8,995	*
1936 ..	14,395	16,244	12,402	*
1937 ..	14,488	17,583	12,996	*
1938 ..	*	*	*	*
1939 ..	*	*	*	*
1940 ..	15,000	18,300	*	*

* Data not available.

A summary of the blast-furnace capacity in the Soviet Union is given in Table II, page 142. Very large units were built. The first large blast furnace, having a volume of 842 cubic metres, was constructed at the Kirovov plant in 1929 and, subsequently, many more of the same size were built elsewhere in Russia. In 1930, the building of the first blast furnace of the standard type, 930 to 1,000 cubic metres volume, was started, based on designs worked out by the Gipromes office—the State Institute for the Design of Metallurgical Plants and Metal-processing Works. A still larger blast furnace, of 1,180 to 1,240 cubic metres, was built in the Magnitogorsk plant. In 1934 and 1935, on the basis of experience thus gained, a design was produced for the largest blast furnace in the world, with a volume of 1,300 cubic metres. The main features of these blast furnaces are given in Table III, page 142. It may be noted that, in 1936, there were,

* Translated from an article by Ing. J. Alexandrovsky in *Hutnicke Listy* (Brno, Czechoslovakia), Nos. 1, 2 and 3, 1946. Abridged.

† References to "tons" are to metric tons throughout.—ED., E.

in the U.S.S.R., 25 blast furnaces with volumes of 800 cubic metres or more each, representing 22·2 per cent. of the total blast-furnace capacity of the country. The corresponding figures for the United States and Germany were 12½ and 3 per cent., respectively.

For maximum efficiency, the operation of the blast furnaces was fully mechanised, which involved the entire re-design of the layout when the second standard type of blast furnace was planned. The "island type," which was chosen, is claimed to be more advanced than American designs. Each blast furnace has its air heaters and pig bed placed diagonally to the direction of the main railway track. Rails are laid all round each furnace, which facilitates uninterrupted operation of the plant when one of the furnaces is under repair. The distance between the furnaces was increased to 124 metres, but the width of the plant was not increased, so that it is possible to expand the older plants by adding further blast furnaces. All apparatus for measuring, signalling, and automatic control of the operation of the blast furnaces, including blowing-in and blowing-down, are concentrated in one room. The valves are electrically controlled, but the operation of the bell and the slag hole is pneumatic.

The older blast furnaces were improved by increasing the diameter of the hearth and the volume of the furnace, providing better cooling of the hearth, the use of better charging equipment to obtain uniform charging, installing larger blowers, air heaters, and more efficient means of cleaning the blast-furnace gas. Charging was improved by mechanising the ore handling more completely and installing automatic charging plant. The furnaces were fitted with control instruments, including automatic registration of the charge level in the furnace, gas analysers, and instruments for measuring the temperature of the furnace walls. In modern plants, it was possible to reduce the period of a charge from between 14 and 16 hours to seven or eight hours, to improve the performance of the furnace from 1·62 to 2·16 cubic metres per ton of production in 1913, to between 0·80 and 0·85 cubic metre per ton, to reduce considerably the alkalinity of the slag, and to reduce fuel consumption from 1·05 to 1·20 ton down to 0·75 to 0·85 ton per ton of pig iron.

The steelworks taken over from previous owners had only a small output, not sufficient to keep the rolling mills fully occupied, because the previous tendency had been to maintain the widest possible range of products, to satisfy any demands that might arise. The Soviet technicians were able to increase the capacity of rolling mills by increasing the output of the heating furnaces, electrifying the drives, and by mechanising the auxiliary operations. Increasing the output of steelworks was more difficult, because the buildings were too small; the spacing between the columns was also too small, and the capacity of the cranes was inadequate. Originally it was intended to build new steelworks immediately, but this plan had to be given up because of the urgent need for rolled sections. The problem of reconstructing the old steel plants has been solved successfully by strengthening the buildings, using more powerful cranes, casting into moulds on trolleys instead of into pits, rebuilding the open-hearth furnaces to take a larger charge, tapping off the steel into two ladles, and increasing the heat capacity of the furnaces. The required increase was achieved by increasing the calorific value of the gas to 2,500 kg.-calories per cubic metre, lagging the furnaces, and increasing the draught, either by heightening the chimneys or by installing exhaust-draught fans. Other measures taken were to reduce friction losses in the gas passages, introduce reversing arrangements of the Blaw-Knox or Schwier types, improve the design of the ports, to fit atomising oil burners, working with a pressure of 10 to 12 kg. per square centimetre, and by introducing secondary air into the furnace.

An increased charge in the open-hearth furnaces was obtained by making the steel bath deeper, as it was impossible to increase the hearth surface in the old plants. Good results were obtained, and designs were therefore developed for open-hearth furnaces with a very short but very deep bath. These designs did not prove successful and have shown that the depth cannot be increased indefinitely; but in many countries the depth of the bath is much less than it might be.

Similar problems were encountered when new steelworks were planned. The output of the Soviet blooming mills has proved to be 40 to 50 per cent. higher than that of the original American designs on which the plants were planned and built. The output of an American steel plant with 12 to 14 open-hearth furnaces of 150 tons capacity is 1·0 to 1·2 million tons a year, which was insufficient for Russian requirements. According to American experience, the best performance is obtained with only nine or ten furnaces in one plant, and it is difficult to run a plant having 12 to 15 furnaces. It was out of the question, therefore, to increase the output by increasing the number of furnaces per plant. To close the gap between the capacity of the steelworks and that of the mills, the output of the steelworks was increased by making the furnaces deeper—to 1,100 mm. or even more, raising the furnace roof by 300 to 400 mm., increasing the draught, and installing more powerful fans for the waste-heat boilers. The charge was increased thereby from 300 to 320 tons, this limit being set by the maximum capacity of the tapping cranes, which were designed to handle 180 tons; each tapping filled two ladles. Usually, open-hearth furnaces are fixed, only furnaces working with pig iron of a high phosphorus content being of the tilting type.

With the above improvements, Soviet steelworks have increased the output per square metre of the hearth 2½ times. The average output over a month is 9 to 9½ tons per 24 hours and, over a year, 7·5 to 8 tons; some furnaces achieved a peak output of 12 to 15 tons per square metre of hearth per 24 hours. The yearly output of one modern open-hearth plant is 140,000 to 150,000 tons of steel, and the fuel consumption has been reduced by 30 to 35 per cent. The numbers of open-hearth furnaces in the U.S.S.R. are given in Table IV, opposite. In 1936, there were 44 open-hearth furnaces taking a charge of over 150 tons each, representing

IRON AND STEEL INDUSTRY IN RUSSIA.

Fig. 2. IRON WORKS IN SOVIET ASIA

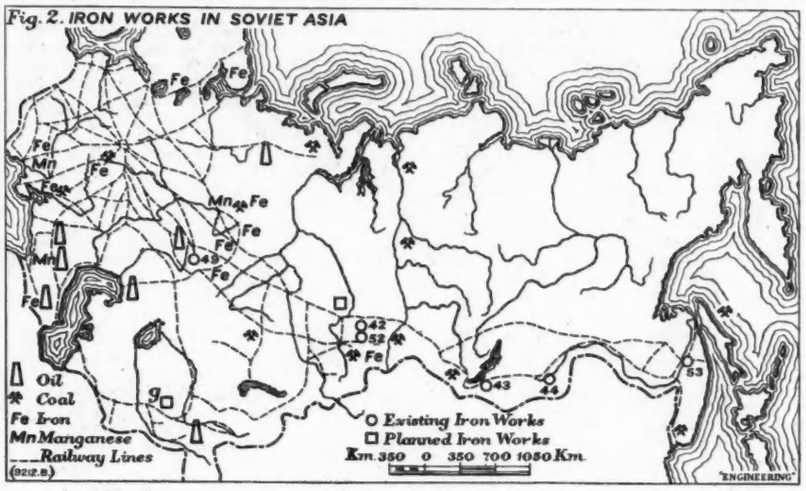


Fig. 3.

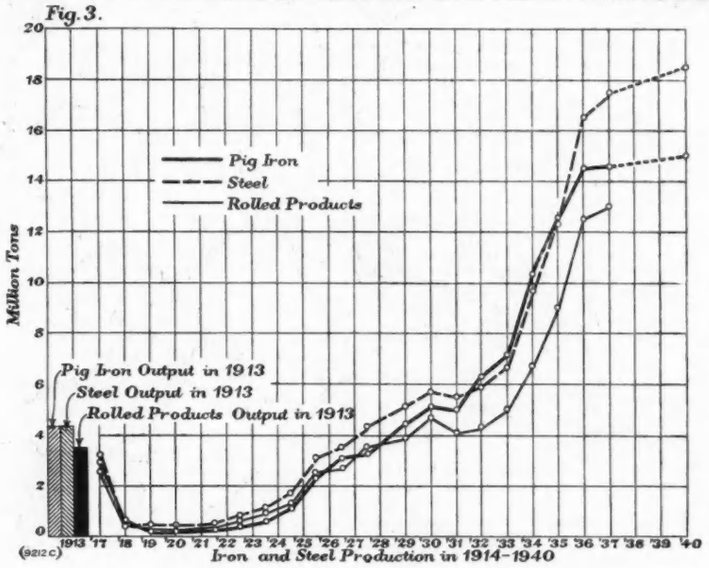


TABLE II.—Blast Furnaces in the U.S.S.R.

Year.	Location.	Number.	Total Volume. Cubic Metres.	Percentage of Total Volume.	Average Volume. Cubic Metres.
1913	Total in Russia	136			
Jan. 1, 1934 ..	Southern U.S.S.R.	43	22,014	60·5	513
	Eastern U.S.S.R.	47	11,131	30·8	239
	Central U.S.S.R.	12	3,139	8·7	262
	Total	102	36,284	100·0	358
1934-37 ..	Built in the 2nd Two-Year Plan ..	18	17,700		985
Jan. 1, 1938 ..	Total in U.S.S.R.	120	53,984		449

TABLE III.—Types of Blast Furnaces in the U.S.S.R.

No.	Type.	Volume. Cubic Metres.	Height. Metres.	Diameter.		Output.	
				Bosh.	Throat.	Tons in 24 Hours.	Tons per Annum.
1	Standard Type I	930–1,000	28·5	7·0	5·41		
2	Magnitogorsk-Kuznec Type ..	1,180–1,204	30·48	7·62	6·1		
3	Standard Type II	1,300	31·0	8·0	6·3	1,500–1,700	500,000

13·4 per cent. of the total capacity. The corresponding figure for the United States was 11·6 per cent. It is particularly noteworthy that high-quality steels also are produced in these large furnaces; it is not true that such steels can only be produced in small slow-working open-hearth furnaces. Brait (*Metal Progress*, June, 1941) supports the Soviet view, stating that the best-quality steels are produced at a rate of 20 tons an hour. The Soviet steelworks produce steel at a still greater rate. In Czechoslovakia, too, it was found that high-quality steels, produced rapidly are more satisfactory than the corresponding steels produced by a slower process. To adapt the new steelworks to the production of high-quality steels, it was necessary to change the method of casting ingots, introducing bottom pouring and redesigning the method of ingot stripping.

TABLE IV.—OPEN-HEARTH FURNACES IN THE U.S.S.R.

Year.	Location.	Number.	Total Hearth Area, Sq. Metres.	Percentage of Total Area.	Average Hearth Area, Sq. Metres.
1913	Total in Russia	260			
Jan. 1, 1934 ..	Southern U.S.S.R.	123	3,298	50·7	26·8
	Eastern U.S.S.R.	72	1,750	26·9	24·3
	Central U.S.S.R.	73	1,463	22·4	20·0
	Total	268	6,511	100·0	24·3
1934-37 ..	Built in the 2nd Five-Year Plan ..	85	3,570		42·0
Jan. 1, 1938 ..	Total	353	10,081		28·4

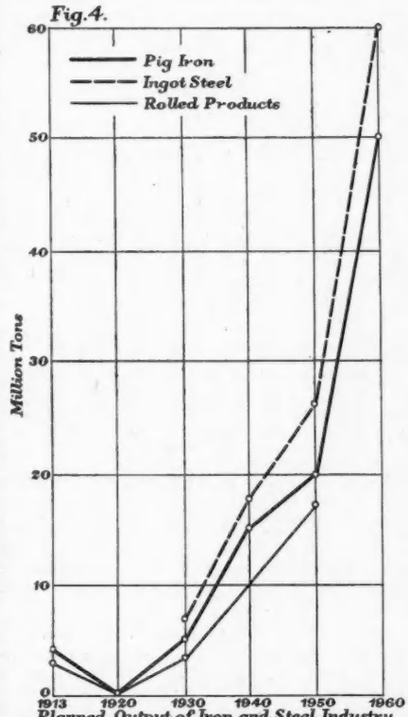
Steelworks of medium size for the production of high-quality steels were originally constructed according to European designs; they were intended to melt scrap and to produce 500,000 tons of steel per annum. The total output of high-quality steels increased from 40,000 tons in 1913 to 3,000,000 tons in 1937. During the first Five-Year Plan the production of high-quality steels was concentrated mainly in the old Ural plants, working with charcoal pig-iron made from selected ores. During the second Five-Year Plan, however, the production of high-quality steels was extended to more steelworks, working with the scrap process, and subsequently, it has also been introduced in to the newly built steelworks. The Bessemer process is not popular in the Soviet Union and only two new plants of this kind have been built there; one of them for the treatment of vanadium iron, from which ferro-vanadium is obtained. Both plants are fitted with converters of 30 tons capacity. Steel production in electric furnaces has developed rapidly and followed closely the increase in the capacity of the electric generating plant. Before the war, the output of electric steels lagged only slightly behind that of the United States.

The advantages of central planning are particularly apparent in the rolling mills. The Soviet mills are built according to American designs, but their output is considerably higher—between 300,000 and 400,000 tons per annum per mill train. This is made possible by the concentration of all orders into one central office, and by specialisation. Ingots of 7 to 9 tons can now be rolled, as against the 5 to 6 tons originally planned, and the weight of the blooms has also been increased. The increased output of the mill trains made it necessary to increase the capacity of the heating installations and the cooling beds, which generally have double the surface area employed in American practice. The ingots are reduced to blooms or slabs in continuous mills, and the process is continuous in the finishing mills also. The mill buildings are well lit and well ventilated, and have high-speed cranes of high load capacities. Nineteen new rolling mills were built during the first Five-Year Plan and 44 mills under the second Five-Year Plan, six of these being blooming mills. Automatic operation is being developed wherever possible.

For the extensive production of high-quality steels, it was necessary to build plants to extract alloying metals from Russian raw materials. The first factory for ferro-alloys was built in the Urals during the first Five-Year Plan; later plants were built in the Dnieper Basin and in the Caucasus region. During the third Five-Year Plan, new plants were built in east Russia, which ensured the supply of ferro-alloys and de-oxidation material for the steel industry during the war.

From the varied research work undertaken in connection with the iron and steel industry, the following items are worth mentioning. Extensive research has been undertaken to increase the supply of coking coals. The operation of blast furnaces has been studied closely, to draw up specifications for the raw materials and the coke, to find the best method of charging, the most advantageous melting process, and composition of the slag in order to decide the optimum dimensions of new large blast furnaces to ensure maximum efficiency. Research on the application of blast containing 25 to 60 per cent. of oxygen for the production of various kinds of pig iron and ferro-alloys has also been undertaken. All this work has been carried out under the guidance of Professor M. A. Pavlov, who with E. V. Bricke, developed a process for smelting the titano-magnetite ores from the Urals, with ferro-vanadium as a by-product. A method has been evolved for melting ores with high content of phosphorus and arsenic, which were considered unsuitable for good-quality steels. Vanadium is obtained from this process also, and fertilisers are a by-product. The resulting steel is said to be especially suitable for rails. Further fields of research are in the production of alloys direct from the ore—especially chromium-nickel and chromium; high-percentage ferro-chromium alloy steels; and the utilisation of alloy scrap. Extensive work has also been carried out on the melting process in open-hearth furnaces having a large charge and very deep bath.

Fig. 4.



Planned Output of Iron and Steel Industry

(92/2 D.) "ENGINEERING"

The Central Institute for the Design of Metallurgical Plants ("Gipromes") was formed in 1926. At first, American experts were invited to act as advisers, but it is claimed that, during the first Five-Year Plan, these proved to be unnecessary because Soviet practice has advanced more rapidly than American practice. The Institute has produced some capable planners and much experience has been gained. Planning in the Soviet Union is guided by the needs of the whole country, combined with the specific needs of the region for which the particular plan is made, and is characterised by extensive standardisation of the equipment and of the individual sections of works. On the basis of research work and experience gained all over the world, various types are designed and their use is compulsory throughout the country. This saves a lot of local planning, ensures a high standard and simplifies the supply of spares and the erection of buildings, which are also standardised. There are three standard types of blast furnaces, having volumes of 600, 1,000 and 1,300 cubic metres, respectively. Sintering plant, the casting beds for pig iron, the equipment of steel plants, scrap stores, ingot stripping, open-hearth furnaces of different sizes, blooming mills, etc., are also standardised.

It is expected that the target of the first post-war Five-Year Plan will be fulfilled. In addition to making good the war damage, this plan aims to increase the production by 1950 to 19·5 million tons of pig iron, 25·4 million tons of ingots, and 17·8 million tons of plates and sections. According to this plan, 45 blast furnaces, 180 open-hearth furnaces, 90 electric furnaces, and 104 rolling mills are to be built or rebuilt. At Cerepovec, it is intended to process ores from Murmansk with coke from the Pecoro-Vorkut coal fields, situated beyond the Arctic Circle, between the Urals and the White Sea. A railway to these coalfields was completed just before the war and the coal from these mines partly replaced the loss of coal from the Donetz Basin during the war. These works are intended to supply steel products to the engineering industry in Leningrad and to enable it to dispense with the steel now delivered from the Ukraine and the Ural region. Plants will also be built in Grosnyi, Rustavi, Aktjubinsk, Orsk (where the ores are rich in nickel and chromium), Novosibirsk and Tashkent. The output planned for the future can be seen from the diagram, Fig. 4, herewith. The target for 1960 was given by Stalin as 50 million tons of pig iron, 60 million tons of steel and 500 million tons of coal.

NOTES ON NEW BOOKS.

Power and Process Steam Engineering. By DOUGLAS COPP. Messrs. Edward Arnold and Company, 41 and 43, Maddox-street, London, W.1. [Price 15*s.* net.]

THE object of this little book is to increase the interest of factory managers and others in the economy of industrial power plants and to emphasise the advantages of combining power production with the use of steam for heating and process work. After an elementary account of the nature and properties of steam, a good deal of the book is taken up with descriptions of equipment available for factory power houses, mostly with illustrations of the kind to be found in manufacturers' literature. The final chapter dealing with the rudiments of electrical generation seems even more unnecessary to those actively concerned with power plants. There is, however, a considerable amount of good advice on the routine maintenance of power plants, the cleaning of boilers, condensers, etc., and the attention required by running machinery. This is, perhaps, the most commendable portion of the book. The treatment of boiler feed-water is touched on, but no tests to check the quality of the water or the operation of the softening plant are given. Combustion matters are virtually ignored, the testing of fuel and flue gases not being mentioned; indeed, the word "test" is not to be found in the index. Since by far the greater part of the controllable losses in a power installation take place in the boiler house, and these losses can only be kept down by careful and continuous supervision of the combustion conditions, the neglect of this aid to economy is rather surprising in a treatise primarily concerned with the efficient use of fuel in factories. There are, however, so many other books dealing with combustion and feed-water treatment that engineers may not suffer from the omission.

Geometry of Construction. By T. B. NICHOLS and NORMAN KEEP, F.R.I.B.A. Cleaver-Hume Press, Limited, 42a, South Audley-street, London, W.1. [Price 7*s.* 6*d.* net.]

FEW engineering draughtsmen now have the opportunity to produce the finished drawings that were customary in most offices in the time of their fathers, but architectural draughtsmen can still do so without being accused of wasting time. This book is primarily addressed to students in the latter field and maintains a correspondingly high standard of draughtsmanship; though the practice of making a fancy border out of the letters of the title is not one to be encouraged. Throughout the book, the drawings and diagrams are on the right-hand page with the relevant descriptive matter facing them on the left, which greatly facilitates reference and study. The scope is that of the building-construction syllabuses of secondary technical schools, and senior architectural courses. A companion volume of progressive practical exercises is projected.

Oil Heating Handbook. By H. A. KUNITZ, M.E. Third edition. Constable and Company, Limited, 10, Orange-street, London, W.C.2. [Price 21*s.* net.]

THIS third edition of a well-known American handbook deals with oil-burning space-heating installations of moderate size. Oil is relatively cheap in America, and the comfort of an American home, warmed by means of an automatic oil-fired air heater, is remarkable. The service is practically trouble-free: the oil company send monthly to fill the tank, adjust the burners, etc.,

and the only responsibility of the tenant is to pay their charges. The technical information in the book includes the relevant codes of the United States Bureau of Standards, the National Board of Fire Underwriters, and other authorities. The physical and chemical properties of various fuel oils are discussed in some detail, with an excellent exposition of the factors involved in combustion; and an account is given of heating methods by steam, vapour, hot water, and warm air, with sufficient data to enable approximate designs to be carried out. Automatic controls are highly developed in America, and a number of these, applicable to oil burning, are illustrated and described. Useful sections deal with the survey necessary before an oil-burning installation is made, with the practical details of the work, and with the servicing of installations in operation. The illustrations and charts are clear and informative, and some specimen forms are given, together with a number of tables, and a useful glossary; but, though oil-burner systems in general are described and classified, no examples of actual burners are given. The book terminates with a chapter addressed "to the salesman," giving much shrewd advice to those whose mission it may be to promote the use of fuel oil. Possibly this indicates the section of the reading public for whom the book is primarily intended, but engineers will find much of interest and value in this virile, clear and typically American work.

Newnes Plastics Manual. By F. J. CAMM, H. W. GILBERT-ROLFE and D. C. NICHOLAS. Second edition. George Newnes, Limited, Tower House, Southampton-street, Strand, London, W.C.2. [Price 17*s.* 6*d.* net.]

DEVELOPMENTS in the composition, manufacture and applications of plastic materials took place so rapidly during the war that publishers are hard put to it to keep abreast of the spate of information released during the past year or so. Not unexpectedly, therefore, the lapse of two years since the first appearance of this manual in 1945 has called for a full revision of the original text, and the addition of much new matter, in order to present a compact and comprehensive review of the plastics industry. The authors have aimed especially at compiling a simple and practical treatise, overlapping into such marginal subjects as rubber and its synthetic alternatives, adhesives, and powder metallurgy, which the non-specialist technical man will understand without difficulty and read with profit. Engineers, in particular, will be interested in the chapters concerned with modern manufacturing processes and machinery, with methods of testing, machining and rectifying plastic materials, and with the latest techniques for reclaiming porous non-ferrous castings by means of Bakelite sealing compounds. The book is well illustrated and is written in such a manner that the limitations of plastics are made no less clear than their attractive possibilities. It thus provides an admirable introduction to the present state of plastics technology.

Industrial Electrification. By J. W. MCQUILLEN, A.M.I.E.E., M.A.Min.E.M.E. Sir Isaac Pitman and Sons, Limited, Parker-street, Kingsway, London, W.C.2. [Price 12*s.* 6*d.* net.]

THIS book describes the problems facing electrical engineers responsible for the planning or maintenance of electrical systems in factories. The author discusses substation and feeder lay-out, transformer and switching arrangements, the choice of cables and motors, power-factor correction, lighting, fire hazards, and methods of earthing. Chapters are also allocated to questions of maintenance, and to the grading of inverse time-limit relays. The book has the advantage of being based largely upon personal experience, and emphasises particularly the need to strive for safety, simplicity, and reliability of service. Some of the points raised are somewhat controversial; for instance, supply undertakings limiting the direct starting of squirrel-cage induction motors to machines of less than 5 h.p. are criticised on the ground that motors of greater power, equipped with starters, may require much higher starting currents. It is implied that starters need not be fitted when the prospective value of the starting current totals less than a third to a half of the full-load current of the transformer supplying that section of the system. The growing practice of fitting large transformers with conservator tanks is recommended as a step towards reducing the growth of acidity in transformer oils. More attention could have been given to the functions of electrical contractors, who, in practice, are often better able than the works engineer to prepare alternative schemes, because they are in closer touch with the makers of electrical equipment. Some reference might have been made to the use of electricity in mines. The book is written in a rather colloquial style, but brings together much scattered information and experience, and should prove useful to electrical contractors as well as to the industrial electrical engineers, to whom it is primarily addressed.

"ENGINEERING" ILLUSTRATED PATENT RECORD.

ABSTRACTS OF SPECIFICATIONS RECENTLY PUBLISHED UNDER THE ACTS OF 1907 TO 1939.

The number of views given in the Specification Drawings is stated in each case; where none is mentioned, the Specification is not illustrated.

Where inventions are communicated from abroad, the Names, etc., of the Communicators are given in italics.

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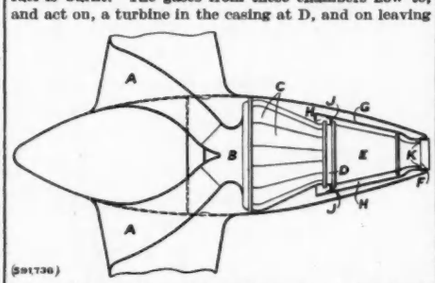
AERONAUTICS.

591,736. Aircraft Turbo-Compressor Apparatus. The de Havilland Aircraft Company, Limited, Hatfield, Hertfordshire, F. B. Halford, of Edgware, Middlesex, and G. Bristow, of Stanmore, Middlesex. (7 *Figs.*) May 11, 1945.—The invention relates to the heat-insulation of turbo-compressor propulsive apparatus for use in aircraft, to reduce heat losses and minimise the risk of fire and damage to parts adjacent to the apparatus. Twin intake passages A lead to a casing B enclosing the impeller of the compressor which delivers air into a series of separate tubular combustion chambers C, wherein fuel is burnt. The gases from these chambers flow to, and act on, a turbine in the casing at D, and on leaving



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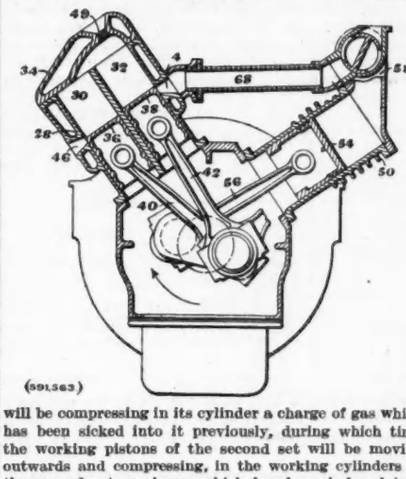
the turbine, pass from the tubular and conical casing E to issue from the nozzle F with propulsive effect. Around the casing E is placed a sleeve G which is conical, like the casing E, but has a larger diameter so that there is an annular lagging space H between the sleeve and the casing E throughout the length of the latter, the sleeve extending also around the casing D, within which is the turbine. Towards its forward end, the sleeve G is supported by brackets J which are circumferentially spaced, while towards its rear end the sleeve is carried by pads K placed between the sleeve and the nozzle F. Thus air constituting a lagging can flow freely within the sleeve along the annular space H and over the casings D and E. This air will issue round the nozzle F, the airflow being induced by the gas jet issuing from the nozzle. (*Sealed.*)

INTERNAL-COMBUSTION ENGINES.

591,563. Two-Stroke Engine. Trojan Limited, of Croydon, Surrey, F. J. Dykes and H. J. Rickwood, of Croydon, Surrey. (5 *Figs.*) May 11, 1945.—This invention relates to a two-stroke engine with an even number of sets of cylinders arranged in pairs of sets, each set consisting of two working cylinders and one charging cylinder, arranged so that the three pistons of a set are connected to the same crankpin of a crankshaft common to them all. A jacketed cylinder block 28, which lies at an acute angle of about 30 deg. to the vertical plane containing the longitudinal axis of the crankshaft, has two pairs of working cylinders spaced apart in the direction of the length of the axis. One of these pairs has working cylinders 30, 32, and a cylinder cover 34 is common to both pairs. The cylinders 30, 32 contain pistons 36, 38, which are respectively connected by connecting-rods 40 and 42 with a crankpin so that their big-ends are spaced apart. The cylinder 32 has an inlet port 4, and the cylinder 30 has an exhaust port 46, and a hole at 49 receives the sparking plug. The combustion chamber or working space of the pair of cylinders has the form of a U. All the cylinders of the set, comprising two working cylinders and a charging cylinder, lie in a plane at right-angles to the axis of rotation of the crankshaft. The two pairs of working cylinders have associated with them two air-cooled charging cylinders, one of which is shown at 50. These are situated outside the crankcase and are connected to the inlet ports of the combustion chambers. The charging cylinders are arranged to induce charges of explosive mixture, and to transfer them to the working cylinders. The charging cylinder 50 contains a piston 54, which is connected by a connecting-rod 56 to the crankpin, and has its big-end lying between the big-ends of the two connecting-rods 40 and 42. The upper end of the charging cylinder opens into a casing 58 containing a rotary device to control suction of the explosive mixture into the charging cylinders and the delivery of the mixture to the two pairs of working cylinders by way of the pipe 68. When the working pistons of the first set are performing their working stroke, the charging piston of the second set



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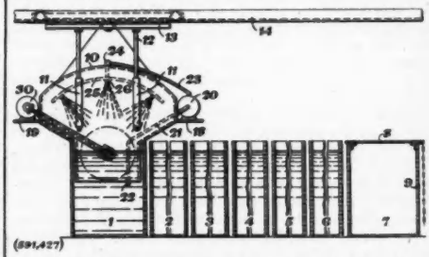
will be compressing in its cylinder a charge of gas which has been sicked into it previously, during which time the working pistons of the second set will be moving outwards and compressing, in the working cylinders of the second set, a charge which has been induced into the charging cylinder of the first set and transferred to the working cylinders of the second set. The gas compressed in a charging cylinder of one set is admitted into the working cylinders of the other set by a working piston in the latter set opening an inlet port 4. (*Sealed.*)

MISCELLANEOUS.

591,427. Coating Metal Surfaces. The Pyrene Company, Limited, of Brentford, Middlesex, and E. Wright and S. J. Scouse, both of Brentford, Middlesex. (2 *Figs.*) May 4, 1945.—In the application of protective coatings to metal articles it is usually necessary to apply a series of treatments to each article; for instance, it may have to be successively cleaned, rinsed, subjected to the action of a chemical solution, rinsed again, treated with another solution and dried. The object of the invention is to provide apparatus which is less costly than the existing spraying plants and in which the duration of each treatment can be varied at will. The plant shown is intended for forming phosphate coatings on box-like articles. These must be subjected to the action of a series of liquids maintained in six tanks numbered 1 to 6, the tank 1 containing a solution of alkali for removing grease, the tanks 2 and 3 cold water for rinsing off the alkali, the tank 4 a solution of metal phosphate for forming the coating, the tank 5 hot water for rinsing the coating and the tank 6 a chromate solution for improving the coating. Finally, there is an oven or tank 7 with a



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hinged lid 8 which can be opened by a chain 9, the articles being dried by hot air while in this oven. The articles to be treated are carried to each tank in turn by a travelling hood 10 which is furnished with four vertical sleeves 11 which engage over rods 12 depending from a carriage 13 mounted to run on overhead rails 14. The hood 10 can move up and down by reason of the sliding engagement of the sleeves 11 with the rods 12. The hood is suspended by four cables which pass over pulleys rotating on a cross-rod in the carriage 13 to enable the hood to be raised and lowered. The hood is also furnished with two side brackets 18 and 19. The bracket 18 supports an electrically-driven pump 20 having a suction pipe 21 which extends downwards and ends in an intake 22 and a pressure pipe 23 which leads to a header 24 connected to a spraying-pipe system 25 with nozzles 26 located inside the hood. The work is fixed in a jig which is secured to a shaft extending across the lower part of the hood 10 and mounted in bearings in the sides of the hood. This shaft is driven by an electric motor 30 which rotates the jig through suitable gearing. (*Sealed*).